User's Primer for **BRI-STARS** (BRIdge Stream Tube model for Alluvial River Simulation)

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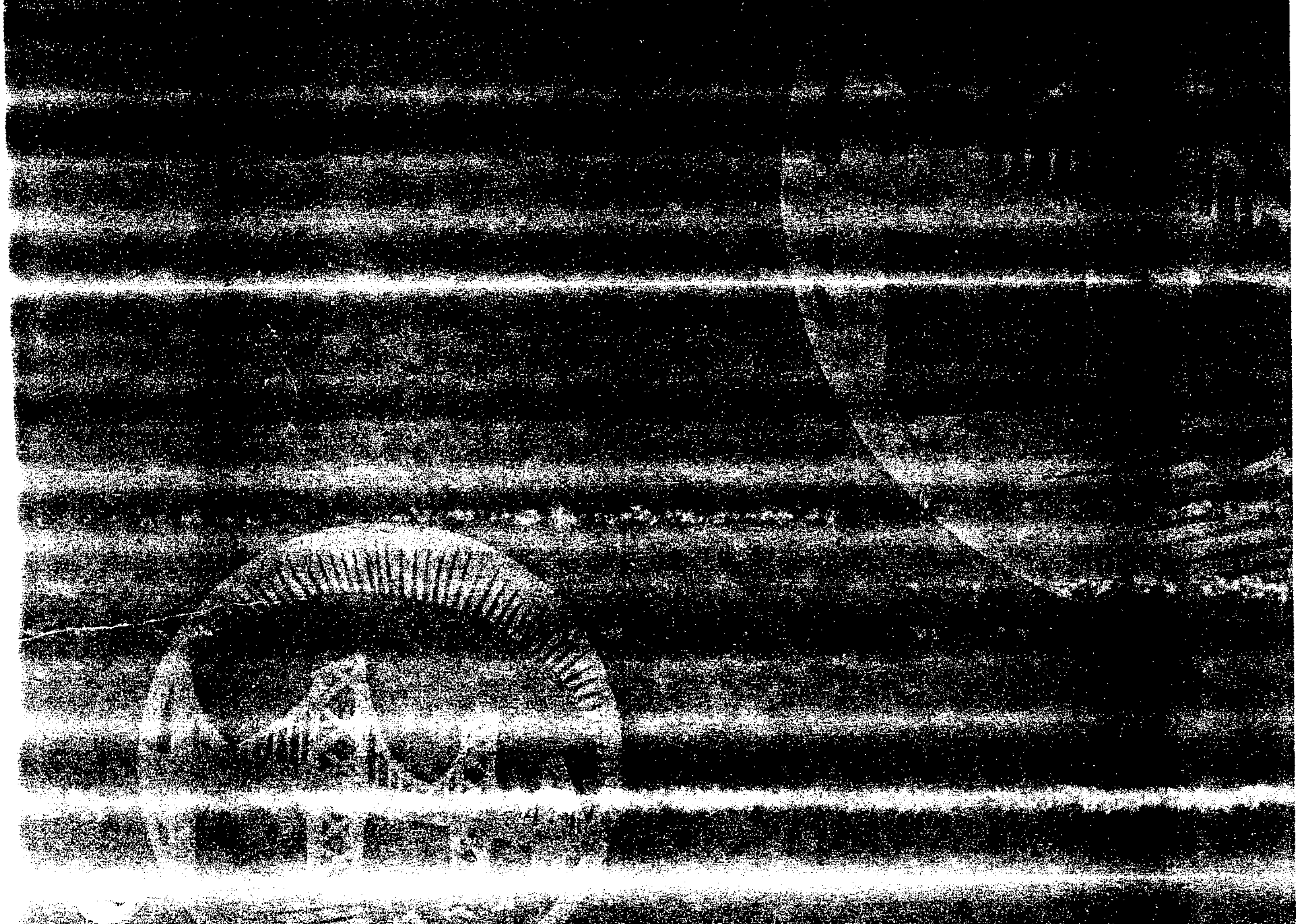

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FOREWORD

This User's Primer provides installation, and operation guidelines for the BRI-STARS (**Bri**dge **St**ream Tube model for **A**lluvial **R**iver **S**imulation) model and a brief description of the model capabilities. This primer is intended to assist users in applying version 5.0 of the BRI-STARS model and was developed as a stripped down version of the User's Manual to facilitate training exercises. This primer also provides instructions for use of utility programs included with the BRI-STARS model. BRI-STARS will be of interest to hydraulic engineers, bridge engineers, and geologists involved in bridge scour evaluations and modeling of general scour in alluvial streams in the vicinity of bridge crossings and highway encroachments. BRI-STARS is especially useful for sites where contraction scour and/or effects of in-stream mining activities are major concerns. This primer as an electronic document along with the down-loadable BRI-STARS software is available through the FHWA Bridge Technology web site at *www.fhwa.dot.gov/bridge* or through the Hydrau-Tech, Inc. web site at www.hydrau-tech.com.

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16. Abstract

BRI-STARS (BRIdge Stream Tube model for Alluvial River Simulation) model is a generalized semi-two-dimensional water and sediment-routing model with an integrated graphical interface for solving complicated river engineering problems with limited data and resources. This model is capable of computing alluvial scour/deposition through subcritical, supercritical, and a combination of both flow conditions involving hydraulic jumps. Unlike conventional water and sediment routing models, it is also capable of simulating channel widening/narrowing phenomena as well as local scour due to highway encroachments. It contains a subset of Federal Highway Administration's WSPRO subroutines for computing bridge hydraulics.

This User's Primer provides a brief description of the BRI-STARS model, installation and operation guidelines, the usage of the various utility programs within the package, and an example application of the model. Detailed instructions for the use of utility programs included in the BRI-STARS package including their menu structures and their operations are given.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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1. GENERAL MODEL INFORMATION

1.1 INTRODUCTION

There is a need for a generalized water and sediment-routing computer model for solving complicated river engineering problems with limited data and resources. This program should have the following capabilities:

- To compute hydraulic parameters for open channels with fixed as well as alluvial boundaries.
- To compute water surface profiles for subcritical, supercritical, and combinations of both flows without interruption.
- To compute and simulate the hydraulic and sediment conditions in the longitudinal and lateral directions.
- To compute and simulate the change of alluvial channel profile and geometry regardless of whether the channel width is variable or fixed.
- To compute the alluvial channel changes in the presence of highway encroachments and/or other man-made or natural structures.
- To compute channel changes in the presence of heavily sediment-laden flows.
- To compute bank failures due to the sediment activity in the presence of severe erosion problems.

Most of the sediment and water routing models, such as the HEC-6, were developed for solving simplified one-dimensional alluvial river problems. Although there are some truly two- or three-dimensional models, they require extensive amounts of computer time and data for calibration. Thus, truly two- or three-dimensional models may not be desirable for solving engineering problems with limited data and resources.

The development of **BRI-STARS** (BRIdge Stream Tube model for Alluvial River Simulation) consisted of three stages. The development of a stream tube model for alluvial channels with fixed width by Molinas was documented earlier. That model was successfully applied to simulate local scour and deposition processes at the Mississippi River Lock and Dam No. 26 replacement site near St. Louis. In the second stage of development, the theory of minimum rate of energy dissipation or its simplified version of minimum total stream power was used to incorporate the channel width as an unknown variable. Finally, in the last stage, the bridge hydraulics and local pier scour component was added. Also, in this third stage, the model's capabilities were enhanced by the inclusion of new sediment transport equations, graphical user interface, lateral water, and sediment inflow options. Both energy and momentum functions are used in the **BRI-STARS** model so the water surface profile computation can be carried out through combinations of subcritical and supercritical flows without interruption. The stream tube concept is used for hydraulic computations in a semi-two-dimensional way. Once the hydraulic parameters in each stream tube are computed, the scour or deposition in each stream tube determined by sediment routing will give the variation of channel geometry in the vertical direction.

BRI-STARS is flexible in its application. When only one stream tube is used, it becomes a one-dimensional model. When the sediment-routing subroutine is not used, it becomes a model for fixed-bed hydraulic computation. When the minimization subroutine is not used, it becomes a model for fixed-channel width. The selection of number of stream tubes and different combinations of subroutines depends on the site-specific conditions, and an engineer's understanding and interpretation of the fluvial processes.

1.2 GENERAL DESCRIPTION OF THE MODEL

The first major component of **BRI-STARS** is based on a stream tube computer model with fixed-channel width to simulate streambed variations in rivers for which sediment and hydraulic data are limited. Using stream tubes allows the lateral and longitudinal variation of hydraulic conditions as well as sediment activity at various cross sections along the study reach. The objective of the model is to study complicated sedimentation problems for which there is interaction between the flowing water-sediment mixture and the alluvial river channel boundaries. In order to accomplish this purpose, the water surface profile and other hydraulic variable computations for supercritical, subcritical, and the combination of both flow conditions must be carried out without interruption. The bed armoring and the breaking of the armor layer is incorporated to study longer periods of flow durations.

The stream tube computer program is a semi-two-dimensional program with the third dimension, depth, being intrinsically incorporated into the computations. As such, it has the basic limitations of every two-dimensional program; secondary flows cannot be simulated. The channel is divided into a preselected number of tubes. The bed elevation in each stream tube is allowed to move vertically up or down, depending on the flow conditions. As a result, while one section of channel is eroding, another section might be aggrading. Depending on the number of stream tubes to be used, the channel cross section changes are averaged across different channel subsections of varying widths. Since the computer time and space are directly related to the number of stream tubes to be used, the user is required to decide on the optimum number of tubes. Bed forms are not simulated due to the lack of a generally accepted methodology for determining them. Even though provisions are made to expand the program to include river confluences and middle islands, at this point these options are not available. The channel boundaries are fixed in the lateral direction and formation of meander bends cannot be simulated.

The computer model using stream tubes can be applied to a variety of river problems. It can be used as a fixed-bed model to compute water surface profiles for subcritical, supercritical, or the combination of both flow conditions involving hydraulic jumps. This option allows the use of applications involving the computation of water surface profiles in man-made channels with clear water, flow profiles over spillways, or flow profiles in natural river channels where the interaction between the sediment-water mixture and the channel bed are negligible. As a movable bed model, the computer program can be applied to route water and sediment through natural river channels. The use of stream tubes allows the variation of hydraulic conditions and sediment activity not only in the longitudinal, but also in the lateral direction. With the selection of a single stream tube, the model becomes one-dimensional. Average channel response to changes in certain riverflow or sediment conditions can be studied. With the selection of multiple stream tubes, the model becomes two-dimensional. The changes in the cross section geometries in the lateral direction can be simulated. Since the bed elevation changes are not averaged over the entire active channel widths as in one-dimensional models, more realistic channel erosion or aggradation can be simulated. This option provides valuable information where certain navigation depths have to be maintained. It can also be used in bank stability problems to identify expected regions of bank instabilities. The armoring process provided in the program allows study of river sedimentation problems for longer periods of time.

The stream tube computer model for routing water and sediment is composed of three computational blocks: (1) backwater computations, (2) stream tube computations, and (3) sediment routing computations. These computational blocks are linked together during the operation of the model.

At each time step, first, backwater computations are carried out for the entire reach with the channel treated as a single tube. Second, with the computed water surface elevations, lateral locations of stream tubes at each cross section are determined. With each stream tube treated as an independent channel, the hydraulic variables along it are computed. Third, sediment is routed through each stream tube satisfying the sediment continuity equation. At the end of these computations, bed material compositions are revised and channel bed elevations are updated. An armoring procedure is incorporated into the sediment routing computations. Computations proceed according to the above format in time steps throughout the entire defined water and sediment discharge hydrographs.

The second major component of **BRI-STARS** is a variable width stream tube model. **BRI-STARS** can be used for decisions as to whether the channel adjustments taking place at a given cross section due to scouring/deposition should advance in the lateral or vertical directions.

The basic tool for this decision-making component is the Minimum Rate of Energy Dissipation Theory developed by Yang and Song (1979, 1986) and Song and Yang (1979, 1980, 1982a, 1982b), and this general theory's special case, Minimum Stream Power Theory used by Chang (1980b).

The Minimum Stream Power Theory states that

> *For all alluvial channels, the necessary and sufficient condition of equilibrium occurs when the stream power per unit length of channel, γQS, is a minimum subject to given constraints. Hence, an alluvial channel, with water discharge Q and sediment load Q_s as independent variables, tends to establish its width, depth, and slope such that γQS is a minimum.*

To extend the minimization procedure to channel reaches experiencing gradually varied flows, stream power (γQS) should be integrated along the channel.

In **BRI-STARS**, selecting directions for channel adjustments is accomplished by this integral expression being minimized for total stream power at different stations. At a given time step, if alteration of the channel widths results in lower total stream power than raising or lowering of the channel, channel adjustments are progressed in the lateral direction. For the opposite case, the adjustments are made in the vertical direction.

At cross sections where sediment erosion is predicted following the sediment routing procedure, channel adjustments can proceed in either deepening or widening directions. The selected mode of channel adjustment in the computer model is the one resulting in the minimum total stream power for the reach.

Similarly, at cross sections where sediment accumulation is predicted, channel adjustments can proceed in raising the bed by sediment deposition on the bed or along the banks. The selected mode of channel adjustment in **BRI-STARS** is the one resulting in the minimum total stream power for the reach. In both the aggrading and degrading channel cases, the sediment load is treated as a constriction in the minimization. In cases where geological or man-made restrictions are applied to the channel deepening or widening processes, computations are performed to accommodate these constrictions.

The amount of channel width adjustment during a time step is determined by the sediment continuity equation. However, for channel widening or narrowing computations, the wetted perimeter P is replaced by the hydraulic radius R. Channel widening of narrowing computations are carried out in the usual way using the sediment continuity equation. The amount of sediment eroded from the banks from a given reach is added into the sediment loads entering that reach in sediment-routing computations. This sediment load becomes influx for the down stream sections that follow to conserve the mass balance.

Finally, the third component of **BRI-STARS** allows the computation of the hydraulic flow variables and the resulting scour due to highway bridge encroachments. **BRI-STARS** performs bridge hydraulics computations utilizing the FHWA's WSPRO water surface profile computation program routines. The details of these computations are described in detail in the WSPRO User's Manual. Also, a second option which utilizes user supplied local loss coefficients at the bridge sections is available. In this simple bridge approach, the bridge loss coefficients can be calibrated with measured/computed water surface profiles for closer agreement with more accurate methods of computations. The simple bridge approach is applicable only for free-surface bridge hydraulics computations since it treats the bridge piers as a part of the channel geometry.

The local scour due to bridge piers in the **BRI-STARS** model is computed utilizing the following methods:

1. Colorado State University/FHWA HEC-18 equation.
2. Jain and Fisher equation.
3. Laursen equation.
4. Froehlich equations.
5. User-supplied generic equation.

The local scour due to abutments in the **BRI-STARS** model is computed utilizing the following methods:

1. Colorado State University equation.
2. Laursen equation for clear-water scour.
3. Laursen equation for live-bed scour.
4. Froehlich equation for clear-water scour.
5. Froehlich equation for live-bed scour.

The model computes and lists the local scour at bridge piers and abutments separately from the computed general stream aggradation/degradation values. The maximum potential local scour value computed during the simulation event is computed and used in the final estimation of cumulative scour at bridge sites. The **BRI-STARS** model also computes the potential contraction scour utilizing Laursen's simplified contraction scour equation and provides users this information for comparison purposes.

1.3 POTENTIAL APPLICATIONS OF BRI-STARS

Potential applications of the **BRI-STARS** can be summarized as follows:

a) The model can be used as a fixed-bed model to compute water surface profiles for subcritical, supercritical, or the combination of both flow conditions involving hydraulic jumps. These computations include but are not limited to:

- Flow profiles in man-made channels with no sediment.
- Flow profiles over spillways and waterways.
- Water surface profiles in rivers where bed elevation changes are negligible.

b) The model can be used as a movable bed model to route water and sediment through alluvial channels.

c) The use of stream tubes allows the model to compute the variation of hydraulic conditions and sediment activity not only in the longitudinal but also in the lateral direction.

d) With the selection of a single stream tube, the model becomes one-dimensional. By selection of multiple stream tubes, changes in cross section geometries in the lateral direction can be simulated.

e) The armoring option allows simulation of longer term riverbed changes.

f) With the selection of the minimization procedure option, the model can simulate channel widening and narrowing processes.

g) With the selection of the WSPRO bridge hydraulics option, the model utilizes specialized routines for the computation of flows through highway bridge openings.

h) Maximum potential bridge pier scour for given flood hydrographs are computed through the use of several equations for various pier geometries.

i) Flow diversion problems can be studied through the use of lateral inflow/outflow options.

j) Aggregate mining studies can be conducted by simulating various mining alternatives (quantity and physical location).

k) Dredging studies can be conducted by the use of the lateral sediment outflow option without any water outflow.

l) Bank failures with known rates of bank regression can be simulated through the option of lateral sediment inflow without water inflow.

2. BRI-STARS PACKAGE

2.1 CONTENTS OF THE BRI-STARS PACKAGE

The package includes:

1) **BRI-STARS** User's Manual.

2) Two 3-1/2 inch MS-DOS formatted high-density floppy disks containing:

- Program Files:

  BST50.EXE - interactive data entry module for **BRI-STARS**.
  BSTPLOT.EXE - visual display program for **BRI-STARS**-generated thalweg and water surface profile output.
  BSTXSEC.EXE - conversion program for **BRI-STARS**-generated cross-section output files to Corel Quattro-Pro-compatible format for the purpose of hard-copy plotting.
  NPPLUS.EXE - Notepad Plus for Windows Text Editor for the integrated development environment.

- Resource Files:

  BRISTARS.RSC - Default file names for BRISTARS.
  BSTPLOT.RSC - Default file name for BSTPLOT.
  BSTXSECT.RSC - Default file name for BSTXSECT.
  BSTPLOT.WSP - Default demo file for BSTPLOT.

- Title Screen Files:

  BSTIMAGE.SYS - Title screen file for **BRI-STARS**.
  BSTPLOT.SYS - Title screen file for BSTPLOT.
  BSTXSECT.SYS - Title screen file for BSTXSECT.

- Help Files:

  BSTHELP.HLP - **BRI-STARS** help file.
  BSTHELP.CNT - Contents file for BSTHELP.
  BSTTHALW.BMP - Bitmap image used in help file.
  BSTTOPO.BMP - Bitmap image used in help file.
  BSTTUBES.BMP - Bitmap image used in help file.
  BSTCONTNTS.BMP - Bitmap image used in help file.

- Examples:

  EXMPL001.DAT - example problem 1 data file.
  EXMPL002.DAT - example problem 2 data file.
  WSPRO.DAT - WSPRO data used in conjunction with EXMPL002.DAT.
  EXMPL003.DAT - example problem 3 data file.
  EXMPL004.DAT - example problem 4 data file.
  EXMPL005.DAT - example problem 5 data file.
  EXMPL006.DAT - example problem 6 data file.
  EXMPL007.DAT - example problem 7 data file.
  EXMPL008.DAT - example problem 8 data file.
  EXMPL009.DAT - example problem 9 data file.
  EXMPL010.DAT - example problem 10 data file.

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- BSTEMPLT Corel Quattro-Pro Worksheet Utility Files:

  BSTEMPLT.WB2 - Input Data Generator Template for **BRI-STARS**.
  I5INPUTH.WB2 - Input Data Generator Template for EXMPL009.DAT.
  BSTGEN.EXE - Quattro PRO-to-BRISTARS data translator program.

2.2 ORGANIZATION OF THE PACKAGE

Organization of the **BRI-STARS** package is illustrated below:

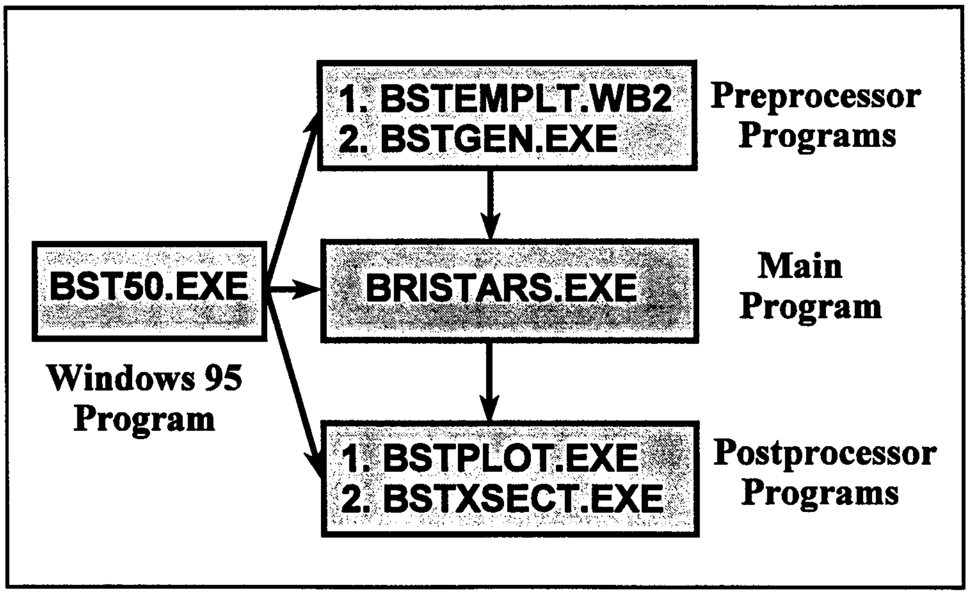

Figure 1. Organization of **BRI-STARS** package.

2.3 TYPOGRAPHICAL CONVENTIONS

Throughout this User's Primer, when you see **Enter** you should press the **Enter** key (which is also called the **Return** key).

In the description of procedures, the items to be typed by the user are shown in upper case lettering. These commands can also be typed in any combination of upper and lower case lettering.

Throughout the User's Primer the computer hard disk is always assumed to be drive C. Drives A: and B: are assumed to be floppy disk drives.

In the explanations pertaining to output generation, it is assumed that the printing device is properly connected to the microcomputer and that the device driver for a plotting device is successfully installed for the plotting package. The user is expected to follow manufacturer's instructions in operating the printing devices to activate appropriate internal printing styles.

2.4 SYSTEM REQUIREMENTS

The system requirements for running the **BRI-STARS** model on a microcomputer are:

- **16 MB main memory (32 MB recommended).**
- Intel Pentium 66 Mhz or higher microcomputer.
- **Windows 95 Operating system.**
- Super VGA (800x600 at 256 color) or higher resolution screen for displaying computed plots.
- **Graphics printer such as HP LaserJet Series II or better.**
- Hard disk with enough room to hold the program, utilities, examples, and output files (Allow at least 10 Megabytes of hard disk space for applications).

3. INSTALLATION

To install **BRI-STARS** on the hard disk, use the automatic Windows 95/NT setup program provided on Diskette 1. The SETUP program is a utility program which automates the installation of **BRI-STARS** by creating a program and examples directory on the hard disk and by automatically copying the **BRI-STARS** model, utility programs, example problem input data, and output files contained in Diskettes 1-2 provided with the package.

1) To run the SETUP program place the Disk 1 into floppy drive A. From the main Windows 95 frame select **START** and then **RUN** options. Type **A:\SETUP** and then press the **Enter** key.

2) A welcoming message describing the purpose of the program will be displayed. To continue with the installation press the **Next** key.

3) At this point, the program licensing screen will be displayed. To continue with the installation, press the **Next** button.

4) The user information screen requests user's name and affiliation. To continue with the installation press the **Next** button.

5) The Destination Location Window requests the installation directory. To accept the default directory of **C:\BSTWIN95**, press the **Next** button. To change the directory name, press the Browse button and enter directory name in the **Path** line. If the directory does not exist, it will be automatically created.

6) The Program Folder Window requests the name of the program folder the **BRI-STARS** program is placed into. To accept the default folder name of **BRI-STARS**, press the **Next** button. Otherwise enter a new name. If the folder does not exist, it will be automatically created.

7) Confirmation Window requests the confirmation of installation information entered by the user. To confirm, press the **Next** button. To change the information, press the **Change** button and reenter information.

8) At this point the installation program copies all files into the specified **BRI-STARS** directory and prompts the user to complete installation by pressing the Finished button.

At this point the **BRI-STARS** program group is created and the **BST50** icon is placed in the program group. To run the program, double click this icon.

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4. OPERATION OF THE MODEL

The logical steps followed in the operation of the model can be listed as:

- Input data preparation.
- Execution of the model.
- Generating output:
  - Computed formatted output.
  - Cross section profile output.
  - Water surface elevation and hydraulic output.

4.1 INPUT DATA FILE PREPARATION

The **BRI-STARS** model operates in a batch mode in which the data needed by the model is provided through a separate data file. This data file can be prepared in several ways. They are:

- Using an ASCII text editor (such as **Wordpad** provided with Windows 95 or the **Notepad Plus** included in the **BRI-STARS** package) and by following the guidelines provided in chapter 6 for hydraulic data, chapter 7 for sediment data, chapter 8 for bridge scour data, and chapter 9 for minimization procedure data.

- By modifying an example problem provided in the package using an ASCII text editor.

- Using the **BSTEMPLT.WB2** template worksheet provided with the **BRI-STARS** package with **Corel Quattro Pro** for Windows.

- Using the **BSTDATA** data entry program provided with the earlier **DOS** version of the model.

4.2 EXECUTION OF THE MODEL

After a successful installation, the executable **BRI-STARS** model and the utility programs are downloaded either into the **C:\BSTWIN95** directory on the hard disk or into a directory defined by the user. The example data files are also copied into the same directory.

In order to run the model, two procedures can be followed. The first procedure involves the use of the main Windows 95 frame, and the second procedure uses the Windows Explorer program.

Method 1—Run BRI-STARS from the main Window:

1) Select **Start** and then **Programs**.
2) Point to the **BRI-STARS** program group from the program list.
3) Double click on the **BST50** icon.

Method 2—Run BRI-STARS Using Windows Explorer:

1) Select the directory in which **BST50** is located.
2) Highlight **BST50.EXE** from the list of files.
3) Double click on the **BST50** icon.

Once the **BRI-STARS** model is activated, an opening screen with program information is presented. To run **BRI-STARS** with the **EXMPL009.DAT** file, the following procedure is suggested:

1) Select **File** from the main menu.

2) Specify the input file name by selecting **Input** from the drop-down menu and then by entering the desired file name (EXMPL009.DAT). Users may also browse through the directory tree using the standard Windows style file browsing utility, and may select other files by highlighting desired files.

3) Specify names for other file menu items:
   - **Output File** - file containing results.
   - **X-Secs File** - file containing cross sections output.
   - **WSP File** - water surface and thalweg elevations output.
   - **Messages File** - file containing miscellaneous messages during execution.

   By default, **BRI-STARS** uses the user-supplied input file name with **.OUT, .XSC, .WSP, .MSG** extensions for naming these files. If these defaults are acceptable, move to next step.

4) Select **Run** from the main **BRI-STARS** menu.

5) Observe screen output:
   - Observe thalweg and water surface elevation changes.
   - Observe stream tubes and velocity distributions.
   - Observe topographic changes during simulation.

6) If results are acceptable, generate output for reporting results.

7) Otherwise, edit the input file by selecting **Edit/Input File** from the main **BRI-STARS** menu and repeat steps 4-6.

8) Continue until satisfactory results are obtained.

At the end of the **BRI-STARS** run described above, if the plotting option is requested for generating water surface profile plots and/or change cross section plots, two data files will be created containing plotting information. The default names for plot data files are XSECTS.XSC and WSPROFS.WSP. The file XSECTS.XSC contains the channel cross section information at each simulation time step, and WSPROFS.WSP contains the water surface profile information. In order to secure these files for future use and to provide proper identification, the user is urged to save these files under different names at run time by specifying unique file identification.

The procedure outlined above can be modified for different applications by altering the names of input and output data files. Since some of the output generated by the model could be very large, the use of floppy drives A: and B: for routing the output from long runs is not recommended. The user should ensure that there is enough storage space on the hard disk for the output (should allow 1-2 Megabytes of hard disk space for IPRLVL=0 for 100 time steps). As a good practice, the user is encouraged to create separate directories for different applications and save the output of each application in these individualized directories.

4.3 GENERATING OUTPUT

At the end of model execution, **BRI-STARS** results are stored in several output files. These files can be imported into a variety of commonly available word processors, desktop publishing programs, and spreadsheet and/or graphics packages for presenting results with varying levels of sophistication. In general:

1) Import the ASCII formatted output file (OUTPUT.OUT) into a word processor to enhance the formatting of the document.

2) Use the post-processor program BSTXSECT provided with the **BRI-STARS** package to manipulate the unformatted Cross Section Output (XSECTS.XSC) file. The BSTXSECT output can be used in conjunction with a variety of plotting/spreadsheet packages to generate report quality cross section plots at various simulation time steps.

3) Import the ASCII formatted Water Surface and Thalweg Profile Output (WSPROFS.WSP) file into a spreadsheet or graphics program to generate tabulated profiles and water surface profile plots.

4.3.1 Formatted Numeric Output

The procedure for generating an output file from successful **BRI-STARS** run is described in the previous section. This output file can be routed to various dot matrix or laser printers for obtaining hardcopy printouts.

Most printers, as a default, operate using a fixed-width font on an 80-column page width in "portrait" orientation setting. **BRI-STARS** utilizes this default setting to format the printouts resulting from sediment routing applications involving up to 5 sediment size groups. For applications involving more than five sediment size groups, to obtain a legible output, a landscape (sideways) font or a 16.6-characters-per-inch compressed font should be used. The compressed and landscape fonts are available in HP LaserJet Series II™ internally. Additionally, by importing the ASCII **BRI-STARS** output into word processor and by using a fixed-width font (such as Letter Gothic or Courier), users may utilize other text enhancements such as bolding, graphic lines, etc.

4.3.2 Cross Section Profile Plots

In order to improve **BRI-STARS**' plotting capacity, a simple approach is taken. In this approach, the model results which are stored in the file XSECTS.XSC are transferred into a format compatible with widely used microcomputer graphics packages.

Step 1 Run the utility program BSTXSEC to convert the format of the cross section output file which is generated by **BRI-STARS** into spreadsheet program-compatible format. The assigned file name for the intermediate file is XSECTS.PRN to follow common file naming conventions.

Step 2 Import XSECTS.PRN into Quattro Pro for Windows or other spreadsheet programs, and create a graph.

Step 3 Generate hardcopy printouts through the spreadsheet or graphics programs.

4.3.3 Water Surface Profile Plots

In order to generate water surface profile plots to display **BRI-STARS** results, a simple procedure is followed. In this procedure, the Water Surface and Bottom Elevations Profile file which is generated at the end of the **BRI-STARS** run is imported into a spreadsheet program as an ASCII numeric file.

To create water surface plots following a successful **BRI-STARS** run, the following two-step procedure is needed.

Step 1 Import a copy of WSPROFS.WSP generated as an output into a spreadsheet programs, and create an X-Y graph.

Step 2 Enhance and print the graph utilizing the graphics tools.

5. VISUAL OUTPUT FROM BRI-STARS

BRI-STARS visual output can be observed in the following screen windows:

1) Thalweg profile window.
2) Stream tubes and velocities window.
3) Topographic changes window.

5.1 THALWEG AND WATER SURFACE PROFILE WINDOW

In a mainframe, thalweg and water surface profile window displays the INITIAL (green line) and the CURRENT (red line) thalweg profiles. In this main plot, the computed water surface profile is indicated by a blue line. In the three vertically stacked minor frames, cross sections are displayed at user selected stations. In the cross section plots, the starting bottom elevations are identified by a green line and the current bottom elevations are shown by a red line. Depending on user options, the water surface line is omitted, shown as a blue line, or shown as a fill. The vertical and horizontal viewing limits of cross sections and the water surface profile viewing boundaries are specified in the PV record.

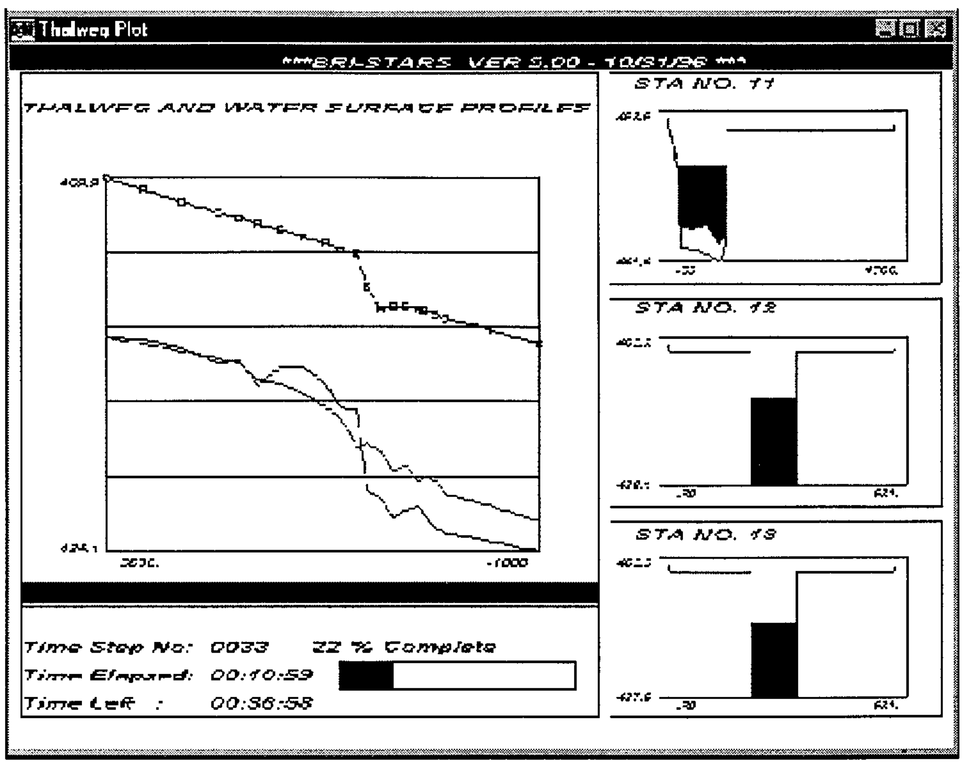

Figure 2. Thalweg and water surface profile window.

5.2 VELOCITIES AND STREAM TUBES WINDOW

In a mainframe, the velocities and stream tubes window displays the current stream tube boundaries. The color-coded contours show computed velocities in a reach by laterally and longitudinally interpolating stream tube velocities. In the three vertically-stacked minor frames, discharge hydrographs at stations specified in the PV records are given. The upstream and downstream reach boundaries for screen viewing are controlled by the PV record.

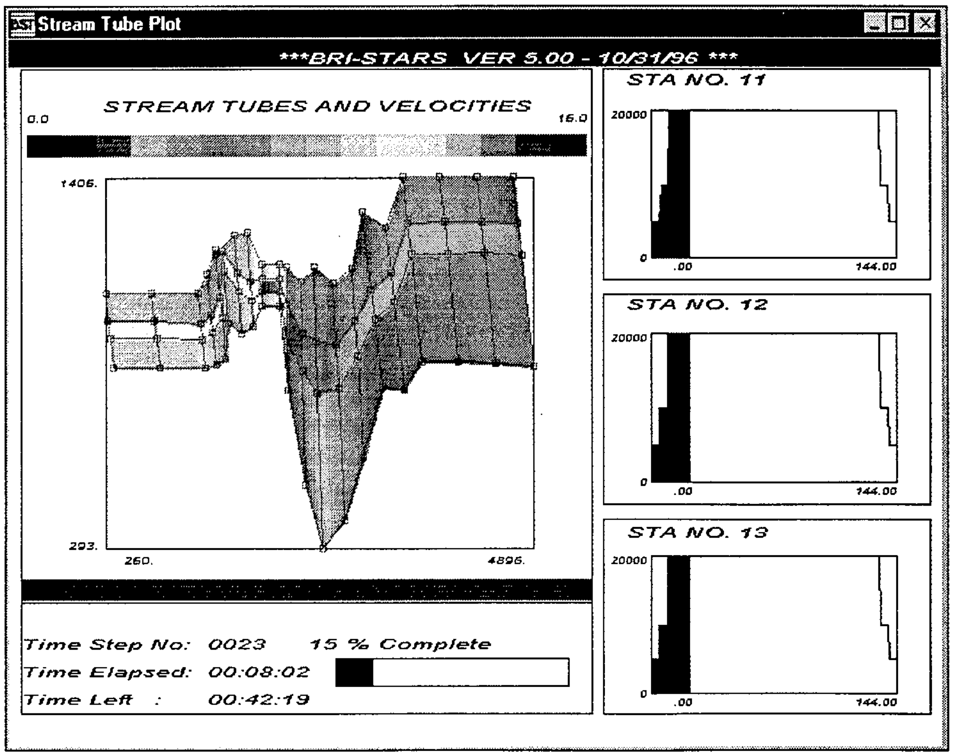

Figure 3. Velocities and stream tubes window.

5.3 TOPOGRAPHIC CHANGES WINDOW

In a mainframe, the topographic changes window displays cumulative bed elevation changes up to the current simulation time step. The color-coded bed elevation change contours show computed scour/deposition at various longitudinal and lateral locations in the study reach. Stream tube boundaries are superimposed onto the screen plots to indicate location of the main flow channel. In the three vertically stacked minor frames, bed-material size distributions are given at selected stations. Upstream and downstream reach boundaries and the stations for discharge hydrograph viewing are controlled by the PV record.

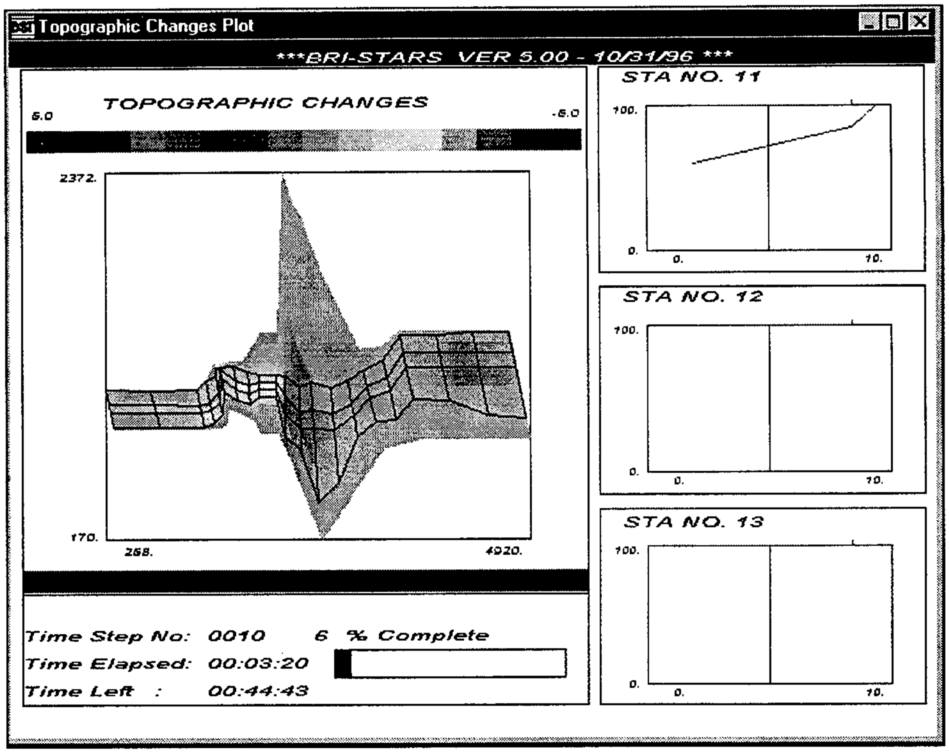

Figure 4. Topographic changes window.

6. ORDER OF BRI-STARS RECORDS

The **BRI-STARS** data file consists of a logical sequence of groups of data. These groups are:

- **Title information.**
- **Channel geometry.**
- **Roughness.**
- **Energy losses.**
- **Stream tube.**
- **Hydrologic information.**
- **Hydraulic boundary conditions.**
- **Sediment transport.**
- **Pier, abutment, and contraction scour.**
- **Printout.**
- **Streampower minimization.**

In general, **BRI-STARS** data files contain the following records in the order listed below:

- Title Information Records:

  TT Title Records.

- Geometric Data Records:

  NS Number of Sections.
  ST Station.
  ND Number of Sub-Division.
  GP Global Positioning.
  XS Cross Section.

- Roughness Data Records:

  RN Roughness Equation.
  RH (or **RB**) Roughness Values/Break Points.

- Energy Losses Data Records:

  CL Coefficients of Local Losses Record.
  CE Coefficients of Expansion/Contraction Energy Losses.

- Bottom Elevations Data Records:

  CB Channel Bottom.

- Stream Tubes and Flow Distribution Data Records:

  NT Number of Stream Tubes Record.

- Hydrologic and Time Step Data Records:

  IT Number of Iterations Record.
  QQ Discharge Record.
  SS Stage Record.

TL	Station Identification for Stage-Discharge Table Record.
SQ	Stage-Discharge Table Record.
DD	Discretized Discharge Record.
RC	Rating Curve Record.
TQ	Table of Discharge Record.
QL	Lateral Water Inflow Record.

- Sediment Data Records:

SO	Sediment Transport Option Record.
QS	Sediment Discharge Record.
SE	Sediment Transport Equation Record.
TM	Water Temperature Record.
SF	Number of Size Fraction Record.
SG	Sediment Size Groups Record.
SD	Sediment Size Distribution Record.
SB	Sediment Size Breakpoint Record.
SX	Size Distribution Across Channel Record.
SL	Lateral Sediment Inflow Record.

- Bridge Scour Data:

PS	Pier Stations Record.
PE	Pier Scour Equation Record.
PP	Pier Scour Parameters Record.
PC	Pier Equation Coefficient Record.

- Screen Output Records:

PV	Visual Screen Output Record.

- Output File Generation Records:

PR	Printout Record.
PL	Plotting Option Record.
PX	Channel Cross Section Plotting Record.
PW	Water Surface Profile Plotting Record.

- Minimization Data Records:

MN	Minimization Option Record.
MI	Minimization Iterations Record.
MR	Bed Elevation/Width Variation Record.

7. DATA NEEDS FOR BRI-STARS

In order to generate a data file for a **BRI-STARS** simulation, the following data is needed:

- **Title Information.**
- **Geometric Data.**
- **Hydraulic Data.**
- **Roughness Data.**
- **Bottom Elevations Data.**
- **Energy Losses Data (Optional).**
- **Stream Tubes and Flow Distribution Data.**
- **Computational Time Step Data.**
- **Stage-Discharge Data.**
- **Sediment Data (Optional).**
- **Sediment Equation.**
- **Sediment Inflow Hydrograph.**
- **Sediment Size Data.**
- **Bridge Scour Data (Optional).**
- **Screen Output Control Data (Optional).**
- **Output File Control Data.**
- **Minimization Data (Optional).**

In the absence of a data group, engineering analysis may be required to extrapolate data from similar watersheds in the geographic region and/or estimations from similar flows.

8. BST-PLOT UTILITY PROGRAM

8.1 INTRODUCTION

The BST-PLOT (BRI-STARS Water Surface Profile Plotting) utility program is used to animate the water surface and bottom (thalweg) profiles computed by **BRI-STARS**. It can be activated at any time during the execution of **BRI-STARS** to view the current water surface profile output or an existing water surface output file generated earlier. By plotting the water surface and bottom profiles with this utility, the water and sediment routing processes can be quickly reviewed, and the simulation results can be visualized.

Table 1. BST-PLOT main menu and its contents.

Menu	Contents	Explanation
File	**Input File**	Select a file for plotting
	Run	Start plotting water surface and bottom profiles
	Stop	Stop plotting
	Goto Frame	Go to a specified frame
	Single Frame Advance	Advance one frame
	Single Frame Reverse	Reverse one frame
	Exit	Exit BST-PLOT and go back to the **BRI-STARS** main window
Edit	**Select All**	Select all contents shown on the screen
	Select Graph	Select graph by highlighting an area on the screen
	Copy	Copy the contents selected by "Select All" or "Select Graph" into buffer
	Print	Print the contents stored in the buffer
View	**Superimpose Bottom Prof.**	Superimpose bottom profile plots
	Superimpose Surface Prof.	Superimpose water surface profile plots
	Grid On	Show grid lines on the screen
	Grid Off	Do not show grid lines on the screen
	Horizontal Axis	Change the minimum, maximum, and incremental values of horizontal axis
	Vertical Axis	Change the minimum, maximum, and incremental values of vertical axis
Speed	**Slow**	Use slow speed to plot the profiles
	Normal	Use the default normal speed to plot the profiles
	Fast	Use fast speed to plot the profiles
Status	**Pause**	Pause the plotting
Window	**Full Screen**	Use full screen to show the profile plotting window
	Status Bar	Hide the status bar at the bottom of the window
Help	**About**	Information about the **BRI-STARS** Water Surface Profile Plotting utility

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The menu bar in the BST-PLOT window uses pull-down menus accordance with standard Windows applications. Each menu and its contents are explained in table 1. The steps in using BST-PLOT utility program are given in the following.

8.2 STEPS IN USING BST-PLOT

Step 1 Activate the BST-PLOT utility program by choosing **View** from the main menu of **BRI-STARS** and then choosing **Animated WSP/Thalweg Profs.**

Step 2 BST-PLOT uses the current water surface and bottom profile output generated by **BRI-STARS** as the default input file for viewing. Users can select a different file to view by using **Input File** under **File** menu command.

Step 3 Choose **Run** under the **File** menu command to view the water and bottom profiles for the selected file.

Step 4 Choose **Exit** under **File** menu command to exit BST-PLOT and to return back to the main window of **BRI-STARS.**

8.3 OPTIONS FOR BST-PLOT

- **To view a specified frame (time step).** To view the water surface and bottom profiles for a specified frame (time step), choose **Goto Frame** under **File** menu, then specify the frame number in the "Goto Frame" dialog box. Click "OK" to view the specified frame. If you click "Cancel," the operation will be canceled.

- **To view the water surface or bottom profiles one frame at a time.** To view the water surface or bottom profiles one frame at a time, you can use the **Single Frame Advance** or **Single Frame Reverse** under the **File** menu. This option will advance or reverse plots by a single frame.

- **To superimpose the water surface or bottom profiles.** The previous water surface or bottom profile plots can be superimposed on the current screen plot for viewing the changes from preview steps. Click on **Superimpose Bottom Prof.** under the **View** menu to turn on or turn off the superimposing of bottom profiles. Similarly, click on **Superimpose Surface Prof.** under the **View** menu to turn on or turn off the superimposing of water surface profiles. By default, superimposing bottom profiles is chosen. Superimposing water surface profiles is not selected by default.

- **To show or hide grids on the screen.** Choose **Grid On** under the **View** menu to show grids on the screen, and choose **Grid Off** under the **View** menu to hide grids on the screen.

- **To specify the view range.** Choose **Horizontal Axis** under the **View** menu, then enter the upstream, downstream, and incremental values of horizontal axis in the "Horizontal Axis" dialog box. Click "OK" to change the horizontal axis to the specified values for viewing. By clicking "Reset," you can set the Horizontal Axis back to the default values determined by the program. Clicking "Cancel" cancels the operation. Similarly, choose **Vertical Axis** under the **View** menu to change and specify the vertical range for viewing.

- **To change the plotting speed.** You can change the plotting speed by using **Slow, Normal**, and **Fast** under the **View** menu. By clicking on **Normal** under the **View** menu, the plotting speed will be set to the normal speed, which is the default speed when you activate the BST-PLOT window. To plot the water surface and bottom profiles with slower speed than current plotting speed, choose **Slow** under the **View** menu. You can repeat click on **Slow** under the **View** menu to reduce the plotting speed. Similarly, you can use **Fast** under the **View** menu to increase the plotting speed. By repeating clicking on **Fast** under the **View** menu, the plotting speed will increase incrementally.

- **To print the water surface or bottom profile plotting.** Use **Select All** or **Select Graph** under the **Edit** menu to select the range of plotting, and then click **Copy** to copy the selected plotting to the buffer. Next, click on **Print** to print the selected graph, or paste to other Window utilities, such as "MS-Paint," for editing.

- **To use full screen plotting.** Choose **Full Screen** under the **Window** menu to show the plotting window using full screen. To hide the status bar at the bottom of the plotting window, click on **Status Bar** under the **Window** menu.

- **To pause the plotting.** To pause the plotting, click on **Pause** under **Status** menu. Clicking on **Resume** resumes the window and continues the plotting.

9. BST-XSECT UTILITY PROGRAM

9.1 INTRODUCTION

The BST-XSECT (BRI-STARS Cross Section Data Conversion) utility program is used to convert the unformatted cross section profiles output computed by **BRI-STARS** into series of x-y-z points for generating 2- and 3-dimensional cross section plots. This utility can be activated from the main menu of **BRI-STARS** at the end of a simulation run by first selecting the **View** option and then choosing the **X-Sectn Data Conversion** option from the pull-down menu. By converting the unformatted data into tabulated "station-distance across channel-elevation" series of points, the model output can be used in a variety of spreadsheet and graphics program to display the simulation results.

Table 2. BST-XSECT main menu and its contents

Menu	Contents	Explanation
File	**Input File**	Select a file for cross-section conversion
	Run	Start data conversion
	Exit	Exit BST-XSECT and go back to the **BRI-STARS** main window
Edit	**Input File**	Use built-in Notepad Plus to view the unformatted cross section file
	Converted File	Use built-in Notepad Plus to view the converted cross section output file
	Print	Print the contents stored in the buffer

9.2 STEPS IN USING BST-XSECT

Step 1 Activate the BST-XSECT utility program by choosing **View** from the main menu of **BRI-STARS**, and then choosing **X-Sectn Data Conversion**.

Step 2 BST-XSECT uses the current cross section profiles output generated by **BRI-STARS** as the default input file for conversion. Users can select a different file for conversion by using **Input File** under the **File** menu command.

Step 3 Choose **Run** under the **File** menu command to activate the conversion process.

Step 4 Choose **Exit** under the **File** menu command to exit BST-XSECT and to return back to the main window of **BRI-STARS**.

9.3 OPTIONS FOR BST-XSECT

- **To generate cross-section profiles at a station at various time steps.** To generate a series of cross section profiles at a station, select **(C)hoose Parts** when prompted if **(E)ntire file** or parts are to be converted. Specify the station number when prompted, and depending on the graphics package format, insert spaces between time steps.

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- **To generate cross-section profiles at all stations at various time steps.** To generate a series of cross section profiles at all stations, when prompted, select **(E)ntire file**.

- **To edit (or view) the converted file.** Select the **Edit** option from the main menu, and then choose the **Converted File** from the pull-down menu.

10. BRI-STARS QUATTRO PRO EDITOR

10.1 INTRODUCTION

The BSTEMPLT is a Quattro Pro worksheet with specially programmed macros (sequences of commands which automate certain procedures) for editing and entering **BRI-STARS** input data. The worksheet is color-coded with cell definitions to facilitate data entry and manipulation. The macros provided in this worksheet allow users to generate data entry templates automatically. By following the instructions given for each cell, users can easily enter their data into the worksheet. If the geometry data, hydrology data, and sediment data are already in a separate worksheet file, these data can be imported into the current worksheet by the "cut-and-paste" facility provided by the Windows 95 environment. After entering the data into the Quattro Pro worksheet, the information can be transferred into the **BRI-STARS** input data format automatically.

The "BSTEMPL.WB2" was developed in Corel Quattro Pro for Windows. In order to use this worksheet, Quattro Pro V6.0 or later for Windows is required.

10.2 STEPS IN USING BSTEMPLT

As shown in figure 5, the three steps in using BSTEMPLT worksheet are: BUILDING A TEMPLATE, ENTERING DATA, and GENERATING **BRI-STARS** INPUT FILE. In the first step, using the built-in macros, a data entry template for the specific problem is generated. This template reflects the basic layout of the data file with properly ordered records. In the second step, the data for each cell in the template is entered manually. In the last step, following the data entry the spreadsheet information is transferred into **BRI-STARS** input data format. The details of using BSTEMPLT are given in the following.

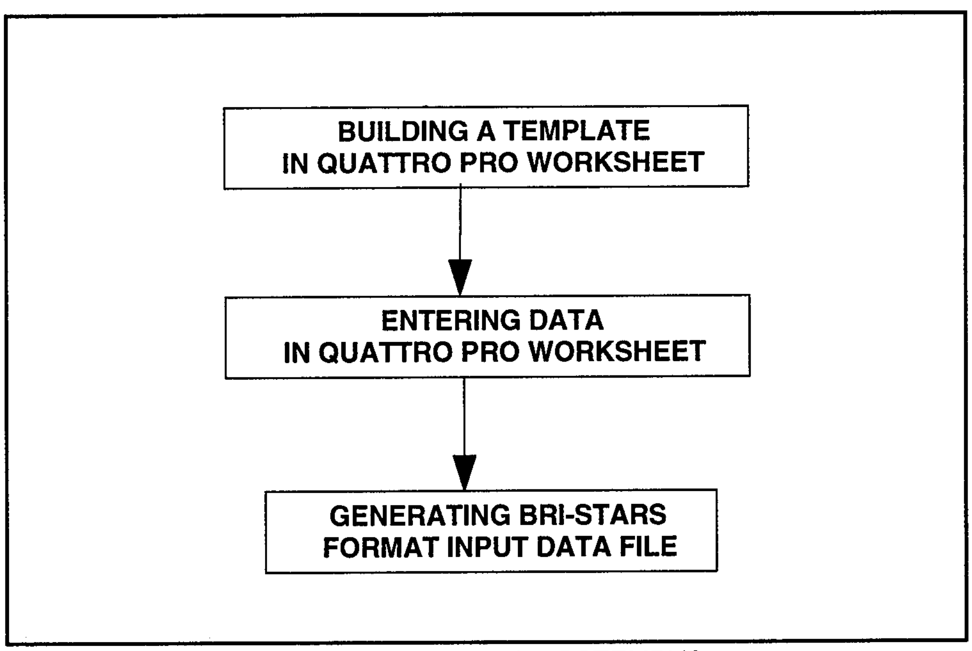

Figure 5. Steps in using BSTEMPLT.

STEP 1. BUILDING A TEMPLATE

1. Get information about your data.

   a) Unit system used in the data, i.e., English units or metric units.

   b) Cross-sectional data information, including the number of cross sections and the number of data points at each cross section.

   c) The number of discretized data values for the stage-discharge data.

   d) The number of discretized data values for the sediment discharge data.

   e) The number of discretized data values for the water temperature data.

   f) The number of sediment size groups.

   *As an example, the **BRI-STARS** input file generated through BSTEMPLT for I5 Bridge data is listed in Examples. The data information collected for this example problem is given in the following.*

   (i) The unit system used in the example problem is English units.

   (ii) Cross sectional data information, including the number of cross sections and the number of data points at each cross section, is listed in table 3.

   (iii) The number of discretized data values for the stage-discharge data is 144.

   (iv) The sediment inflow discharge at upstream boundary is 300,000 tons/day for 144 time steps.

   (v) The water temperature is 55°F for 144 time steps.

   (vi) The number of sediment size groups is 3.

Table 3. Cross sectional data information for I5 Bridge data.

No. of Cross Sections	No. of Data Points		No. of Cross Sections	No. of Data Points		No. of Cross Sections	No. of Data Points
1	29		8	26		15	26
2	29		9	24		16	22
3	29		10	26		17	17
4	29		11	18		18	26
5	26		12	18		19	13
6	28		13	18		20	13
7	26		14	20		21	13

2. Open "BSTEMPLT.WB2" in Quattro Pro (Version 6.0 or later) for Windows to start a new data entry task and save it under a different name. Leave the original "BSTEMPLT.WB2" unchanged.

   Note: For this step, the default startup macro \0 is needed. To check your startup macro, you may right-click on the Corel Quattro Pro title bar and choose Application Properties from the QuickMenu or pull down the Edit menu and choose Preferences. The window titled Startup Macro in the Macro tab displays the startup macro. This entry must be set to \0. If it is not \0, modify the entry and reopen the "BSTEMPLT.WB2."

For example, after "BSTEMPLT.WB2" is opened, you save it as "BSTINPUT.WB2". From now on, you will work in the Quattro Pro file "BSTINPUT.WB2".

3. Click the quick button **Change Unit System** to specify the unit system. If the unit system in cell B6 is already in the one you need, then you can skip this step.

   For the example problem, choose "English Unit System."

4. Move cursor down to the "NS" record line and enter the number of the cross section. Then click on the quick button **Generate Cross Section Template** to generate a cross sectional template for the specified number of cross sections.

   For the example problem, you enter 21. Then click on the **Generate Cross Section Template** *button and choose "GENERATE AND ADJUST SECTION TEMPLATE"; next choose 'USE SPECIFIED NO. OF SECTIONS: 21". For slower computers, this step may take a while; you should wait until finished.*

5. Move cursor to the "ST" record for cross section number 1, and enter the number of data points. Then click on the quick button next to it to automatically adjust the number of "XS" records, so that the number of "XS" records matches the number of data points specified in "ST" record for section 1. Before you use the quick button, make sure the cell showing Number of Points at Station 1 is highlighted.

   For the example problem, go to the cell requiring the number of data points for cross section no. 1 and change the default value of 50 to 29.

6. Repeat step 5 for all cross sections to specify the number of data points and adjust the number of "XS" records for each cross section.

   For the example problem, you enter the number of data points given in table 3 for other cross sections and adjust the number of "XS" record using the quick button.

7. Move the cursor down to the "RH" record. Then click on the quick button **Adjust No. of "RH" Records if any No. of Sections or Points Changed** to automatically adjust the number of "RH" records for each cross section.

8. Move the cursor down to "IT" record, and enter the number of time iterations.

   For the example problem, you enter 144 for the number of time iterations.

9. Move the cursor down to the "SQ" record. Then click on the quick button **Generate & Adjust Stage-Discharge Record Template** to generate the stage-discharge data template.

   For the example problem, you follow the Macro Menu and choose "GENERATE & ADJUST 'SQ' RECORD TEMPLATE," and then choose "USE THE VALUE SPECIFIED IN 'IT' RECORD: 144." You can choose "ENTER NEW VALUE" to specify a new value when needed.

10. Move the cursor down to the "QS" record. Then click on the quick button **Generate & Adjust Sediment Discharge Record Template** to generate the sediment discharge data template.

For the example problem, you follow the Macro Menu and choose "GENERATE & ADJUST 'QS' RECORD TEMPLATE." Then choose "ENTER NEW NUMBER FOR SEDIMENT DISCHARGE RECORDS," enter 1, and click "OK." Choose "USE SPECIFIED NUMBER FOR "QS" RECORD: 1."

11. Move the cursor down to the "TM" record. Then click on the quick button Generate & Adjust Water Temperature Record Template to generate the temperature data template.

    For the example problem, you follow the Macro Menu and choose "GENERATE & ADJUST 'TM' RECORD TEMPLATE." Then choose "ENTER NEW NUMBER FOR TEMPERATURE RECORDS," enter 1, and click "OK." Choose "USE SPECIFIED NUMBER FOR "TM" RECORD: 1."

12. Move the cursor down to the "SF" record. Then enter the number of size fractions. Click on the quick button next to it to adjust the number of "SG" records so that the number of "SG" records will match the number specified in the "SF" record.

    For the example problem, you enter 3.

STEP 2. ENTERING DATA

Once the general data layout is generated, the specified data for each cell in the worksheet is entered according to the instruction for each cell. The instruction for each cell in the worksheet is labeled in red (required data) or green (optional data).

- You can enter the data manually by following the instructions and entering the corresponding data for each cell.
- Data from an existing spreadsheet file can also be imported by the cut and paste facility in the Windows environment into the current worksheet.

STEP 3. GENERATING BRI-STARS INPUT FILE

The information that has been entered into the Quattro Pro worksheet needs to be transferred into **BRI-STARS** input format. This is done by clicking on the button Generate **BRI-STARS** Format Input File When Finished Filling BSTEMPLT.

*For the example problem, when you click on the quick button, **BRI-STARS** input file "BSTINPUT.DAT" is generated. The Quattro Pro template file for I5 Bridge is provided in the **BRI-STARS** package under the file name "I5INPUT.WB2." You can compare your template file "BSTINPUT.WB2" for the I5 bridge data with "I5INPUT.WB2".*

10.3 NOTES

- Color codes used in the worksheet are as follows:

  Red—data field description.
  Blue—user instruction and tips.
  Green—optional fields which may be left unchanged.
  Black—fields which must be filled by the user.

- The macros are stored in pages MACRO and RESOURCES. Do not use these pages for data editing.

- If you create a block name, be sure not to overwrite existing block names.

- The default values provided in the template file "BSTEMPLT.WB2" are as follows:

  - English unit system.
  - 10 cross sections having trapezoidal shape with main channel and left/right floodplain.
  - 50 data points for each cross section.
  - 3 channel subsections.
  - Manning roughness value of 0.025.
  - Coefficients of contraction and expansion losses: 0.1 and 0.3.
  - 3 stream tubes.
  - 20 time iterations.
  - 20 discretized water discharges.
  - 20 discretized sediment discharges.
  - Yang's Sediment transport equation.
  - Active layer thickness multiplier of 50.
  - 20 discretized water temperatures.
  - 5 size fractions in the sand size range.

11. LIST OF BRI-STARS EXAMPLES

The **BRI-STARS** package is supplied with a series of examples to demonstrate the various options available in the model. The summary listing is given in table 4 with the feature of each example.

Table 4. Examples for **BRI-STARS** and their features.

Example File	Explanation and Features
EXMPL001.DAT	• CSU Laboratory study • Default Screen Plotting • RH record to change n=0.02 to 0.04 behind piers • IT record to set convergence limit to 0.0001 ft • CL record to set CL=1 • NT record to set number of tubes to 4
EXMPL002.DAT	• Dry Creek example with WSPRO input • IT to set convergence criteria to 0.1 ft • SF record to set single sediment size • WB to use WSPRO data directly
EXMPL003.DAT	• Hatchie Data (USGS) • 6 sediment time steps within one hydraulic time step • PV records • PX record for generating cross section files
EXMPL004.DAT	• CSU Laboratory Data • PS, PE records for local pier scour • PV records with zooming • RH record to change n=0.02 to 0.04 behind piers • CL set to 1 at U/S station • IT to set level of accuracy in hydraulic computations
EXMPL005.DAT	• CSU Data • CM Comment record • TM to set temperatures to 70°F • Simulation of piers by altering x-sections
EXMPL006.DAT	• Lower Tornillo study • RH to show natural channel roughness distribution • PR to control printout • NF, SG, SD records for sediment routing in graded beds
EXMPL007.DAT	• Red Fox • Global positioning records
EXMPL008.DAT	• Man-made channel • RC records for multiple rating curves • DD records for discretized discharges
EXMPL009.DAT	• I5-Bridge data • Global positioning • Natural river data
EXMPL010.DAT	• I5-Bridge data • Date-Time function for variable time increment step

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12. SIMULATION OF I5 BRIDGE SITE

The California I5 Bridge Site is located at the Los Gatos Creek study reach downstream from I-5. Severe scouring happened in this study reach during the flood on March 11, 1995. This study aims at estimating the contraction scour at the California I5 bridge site during the flood by applying **BRI-STARS** with limited available data. Figure 6 is the plan view of the study reach. The locations of the eight cross sections and the high water edges measured by U.S. Geological Survey (USGS) on March 20 and 21, 1995, are shown in this figure.

12.1 SELECTION OF SIMULATION DATA

The data needed for the numerical simulation of the study reach can be classified into the following categories: i) channel geometry data, ii) roughness and energy losses data, iii) hydrology data, and iv) sediment data.

The available channel geometry data are the channel cross sectional data measured after the flood on March 20 and 21, 1995. There are four measured cross sections (USGS sections nos. 9, 8, 7, and 6) at upstream of the bridge and four measured cross sections (USGS sections nos. 3, 2, 1.5, and 1) at the downstream of the bridge. Locations of the measured cross sections are shown in figure 6. The cross section profiles of these measured sections are plotted in figures 7-14. It is assumed that these cross sections represent the boundary conditions before the flood. There are no cross sections measured at the bridge location. Two cross sections are generated for the bridge contraction using USGS sections nos. 6 and 3 and the plan view (figure 6) of the reach. These two generated cross sections are shown in figures 15-16.

Figure 17 is the plan view of the location of cross sections used for simulation. In this figure, cross sections nos. 12 and 13 are the two cross sections generated for the bridge location; cross sections nos. 1-3 and 20-21 are propagated cross sections extending the existing bottom slope using sections nos. 4 and 19 (USGS sections nos. 9 and 1), respectively. Sections nos. 5, 7-8, 10, 15, and 18 are cross sections interpolated using the corresponding upstream and downstream measured sections. These cross sections are also listed in table 6.

The available hydrology data is the hydrography measured at D.W.R. Station, Los Gatos Creek at Eldorado Avenue, shown in figure 18, and the high water surface elevation shown in figure 19. From figure 18, it can be seen that the time duration of the flood that occurred in March 11, 1995, was about one day. The average peak flow discharge is about 20,000 cfs (cubic feet per second) according to the estimation of J. Sterling Jones (Federal Highway Administration). From figure 19, it can be seen that the high water surface elevation at station no. 19 (USGS station no. 1) is about 450.5 feet. The water surface elevation at downstream control station no. 1, which is 1000 feet downstream from section 19 (USGS station no. 1), was determined to be 448.5 feet.

There are no available roughness and energy losses data. The Manning roughness values in the main channel of the reach are about 0.04 according to J. Sterling Jones' estimation. The local energy loss coefficients at bridge location are calibrated according to the high water surface shown in figure 19.

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The bed material size was determined to be 0.2-0.3 millimeters according to J. Sterling Jones. The inflowing sediment discharge into the study reach was determined to be 300,000 tons per day (6,000 parts per million) through calibration.

Table 5. Measured, interpolated, and propagated cross sections.

Cross Section No.	Distance along the Channel (ft)	USGS Measured Section	Interpolated or Propagated Section
1	3600.0		Propagated
2	3200.0		Propagated
3	2800.0		Propagated
4	2398.5	SEC-9	
5	2187.0		Interpolated
6	1976.5	SEC-8	
7	1740.0		Interpolated
8	1502.0		Interpolated
9	1265.5	SEC-7	
10	1098.0		Interpolated
11	932.4		Interpolated
12	830.5		Interpolated
13	675.5		Interpolated
14	543.0	SEC-3	
15	412.0		Interpolated
16	281.5	SEC-2	
17	221.2	SEC-1.5	
18	110.2		Interpolated
19	0.0	SEC-1	
20	-5000.0		Propagated
21	-1000.0		Propagated

12.2 NUMERICAL SIMULATION

An input data file is generated according to the information discussed above. A total of 21 cross sections, including 8 USGS measured sections, 2 bridge sections, and 11 interpolated and propagated sections are used. The number of discretized stage-discharge values is 144, and the time increment is 0.00694 day (10 min). For the sediment routing, Molinas and Wu formula is used to compute the transport rate in the computations. The computed water surface and bottom profiles at time steps 1, 48, 96, and 144 are given in figure 20. In this figure, the variations of water surface and bottom profiles versus time can be seen.

From the results computed by **BRI-STARS** with limited available data, severe scouring can be seen since the bridge contraction during the one-day flood. At the upstream of the bridge, the sediment was deposited at the initial phase of the flooding because the water was blocked by the bridge contraction. This deposition is reduced with the progress of time. Finally, It is changed to scouring from deposition. The maximum scouring occurred at the bridge location. The maximum scouring depth is about 9 feet at the bridge location.

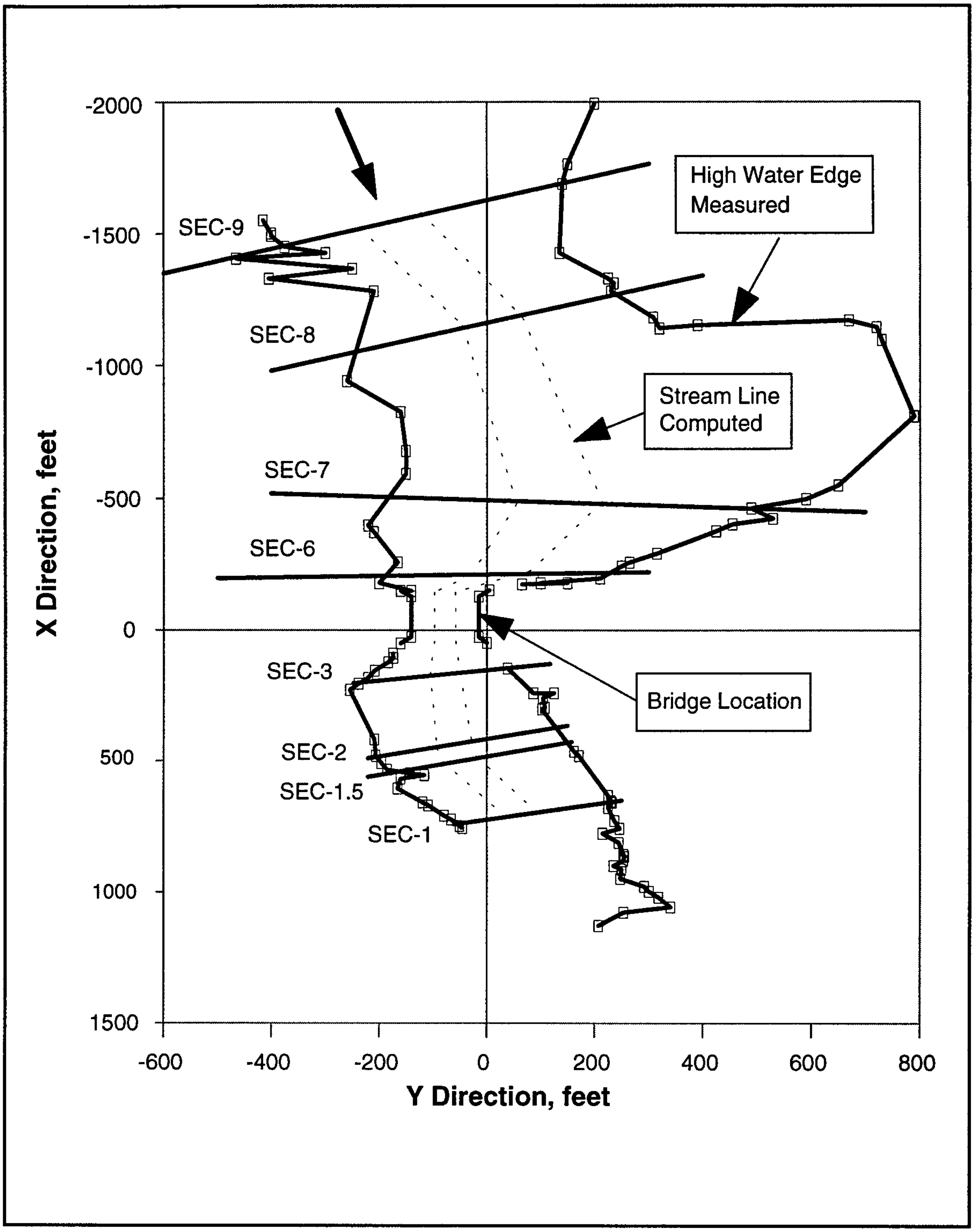

Figure 6. Plan view of the study reach at California I5 bridge.

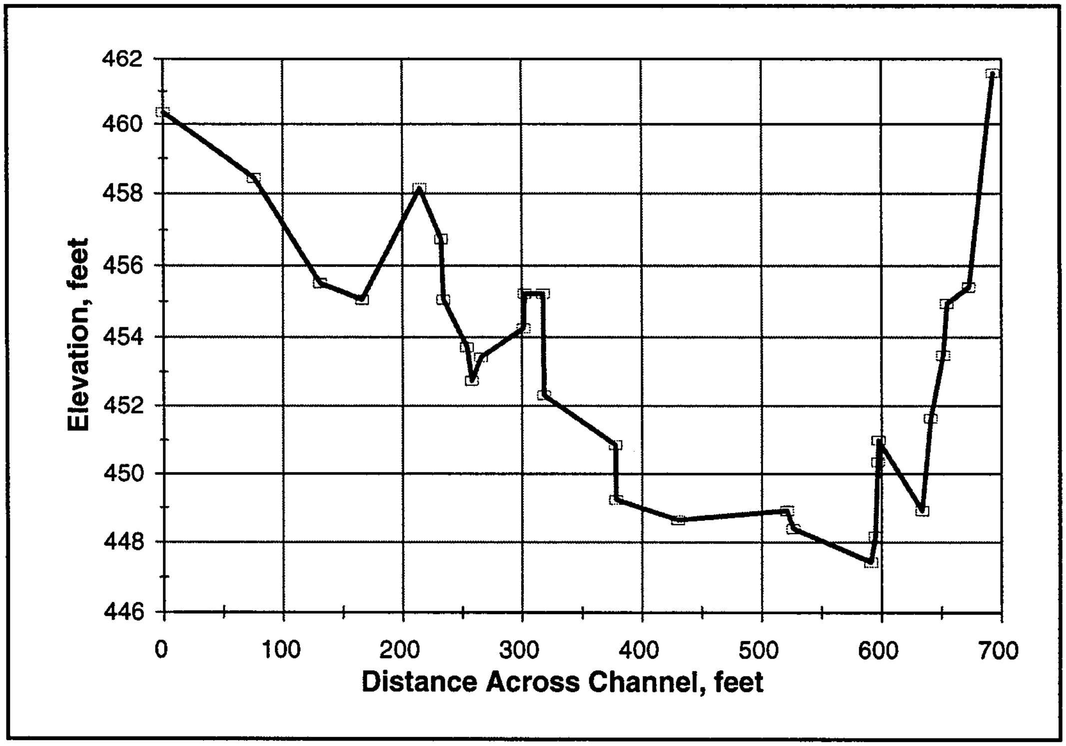

Figure 7. USGS measured cross section no. 9.

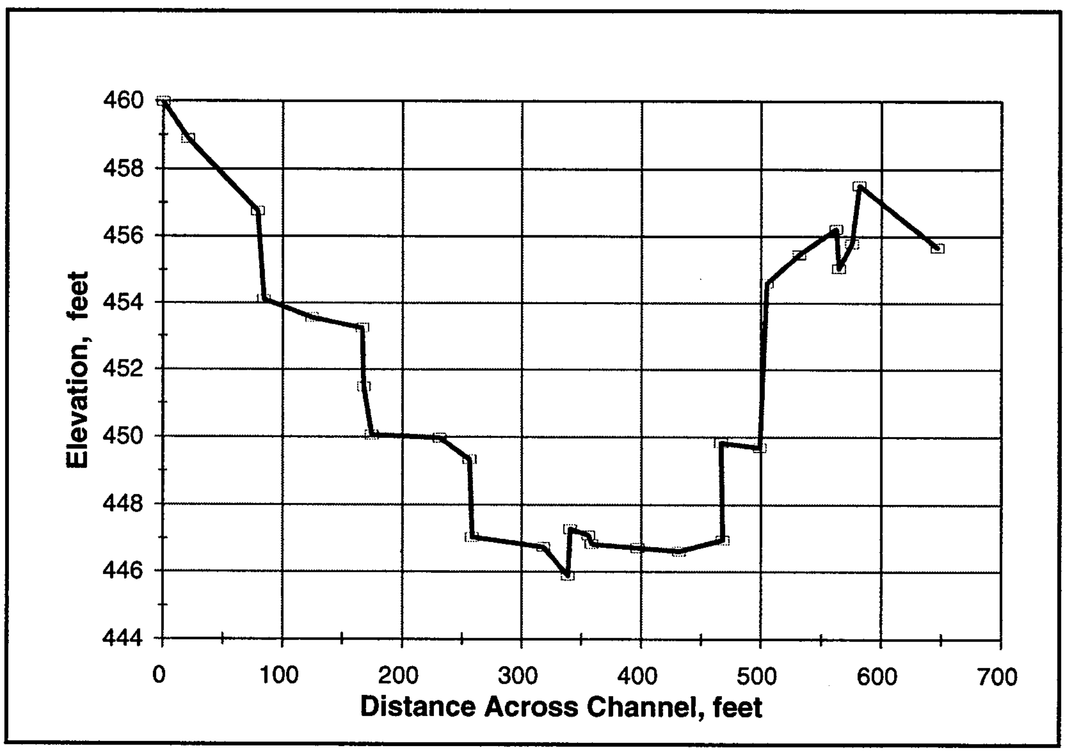

Figure 8. USGS measured cross section no. 8.

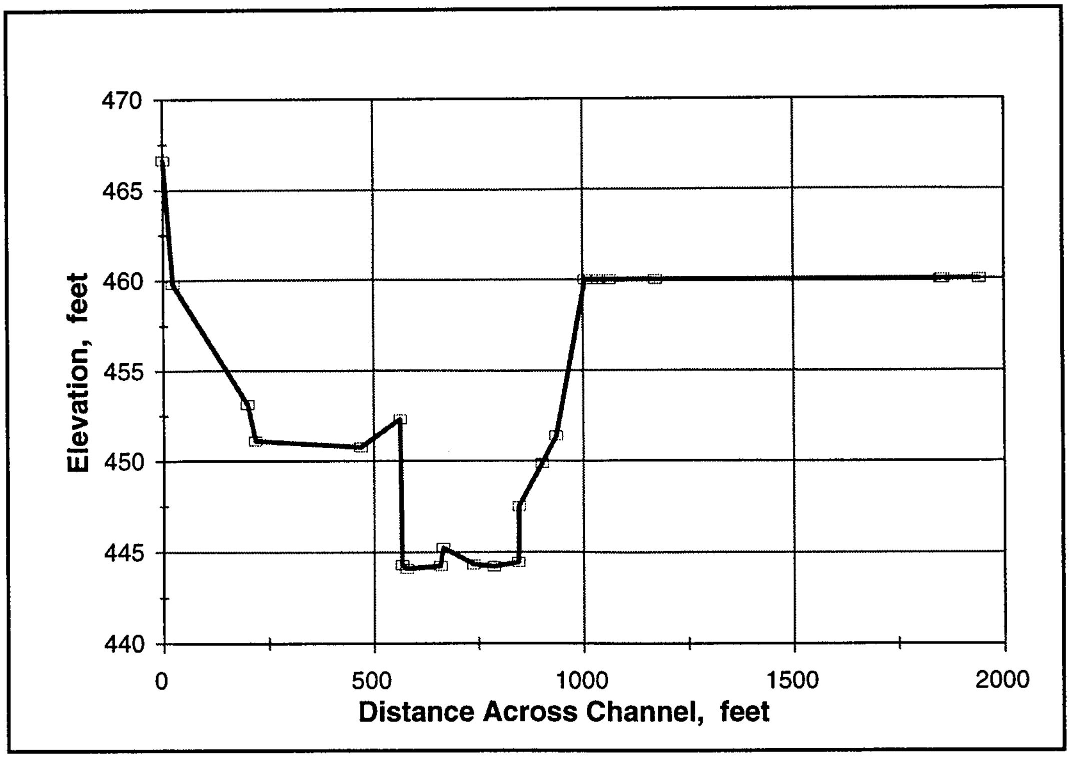

Figure 9. USGS measured cross section no. 7.

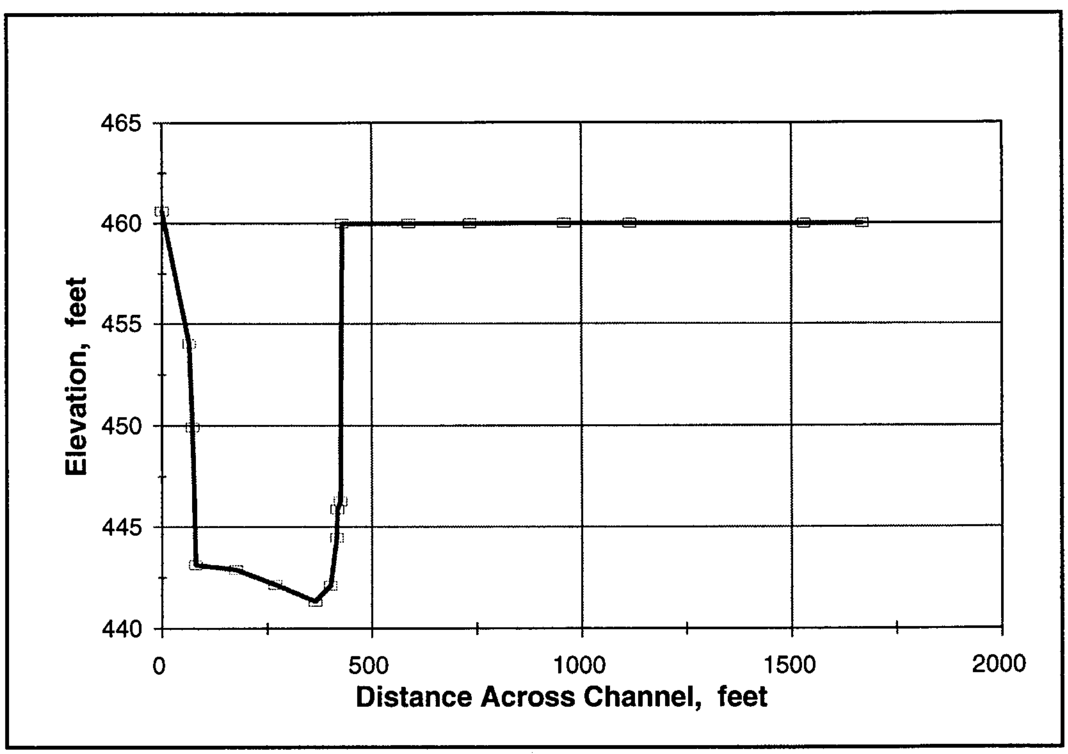

Figure 10. USGS measured cross section no. 6.

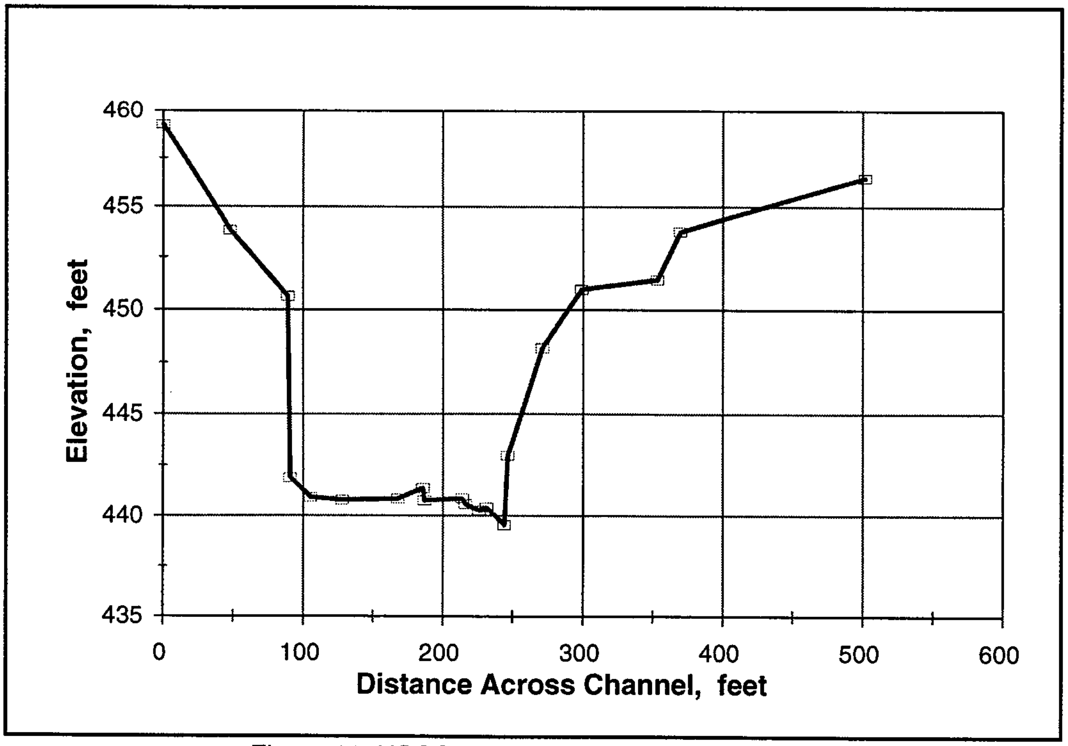

Figure 11. USGS measured cross section no. 3.

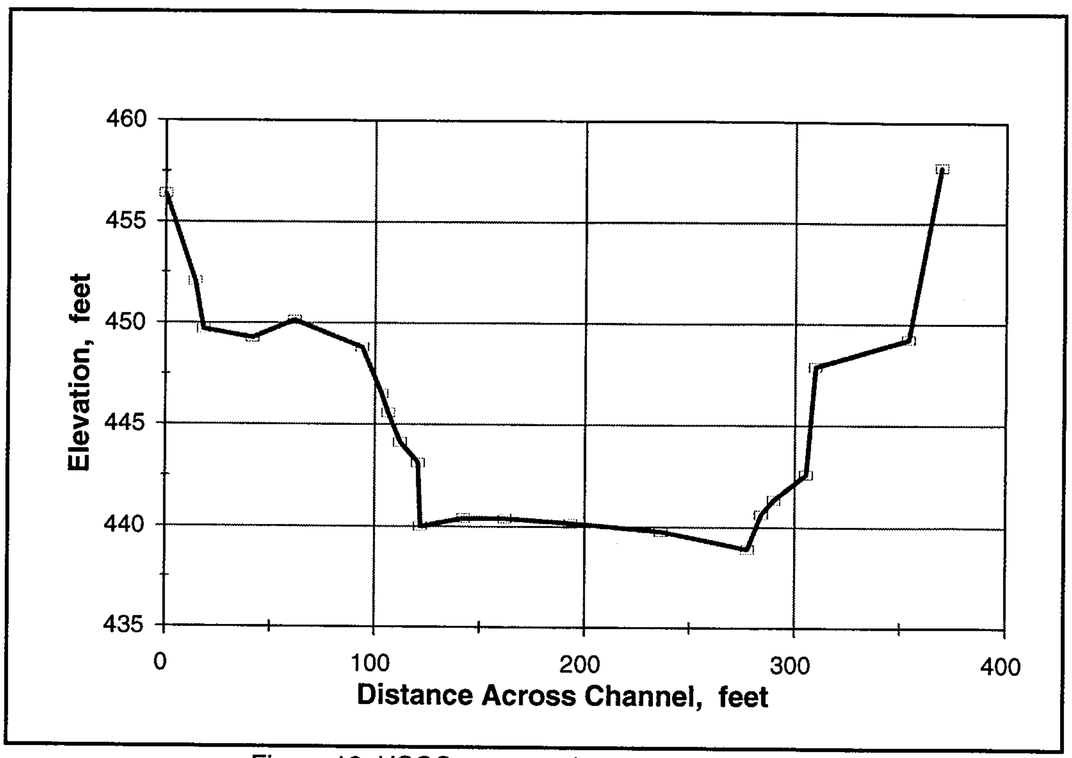

Figure 12. USGS measured cross section no. 2.

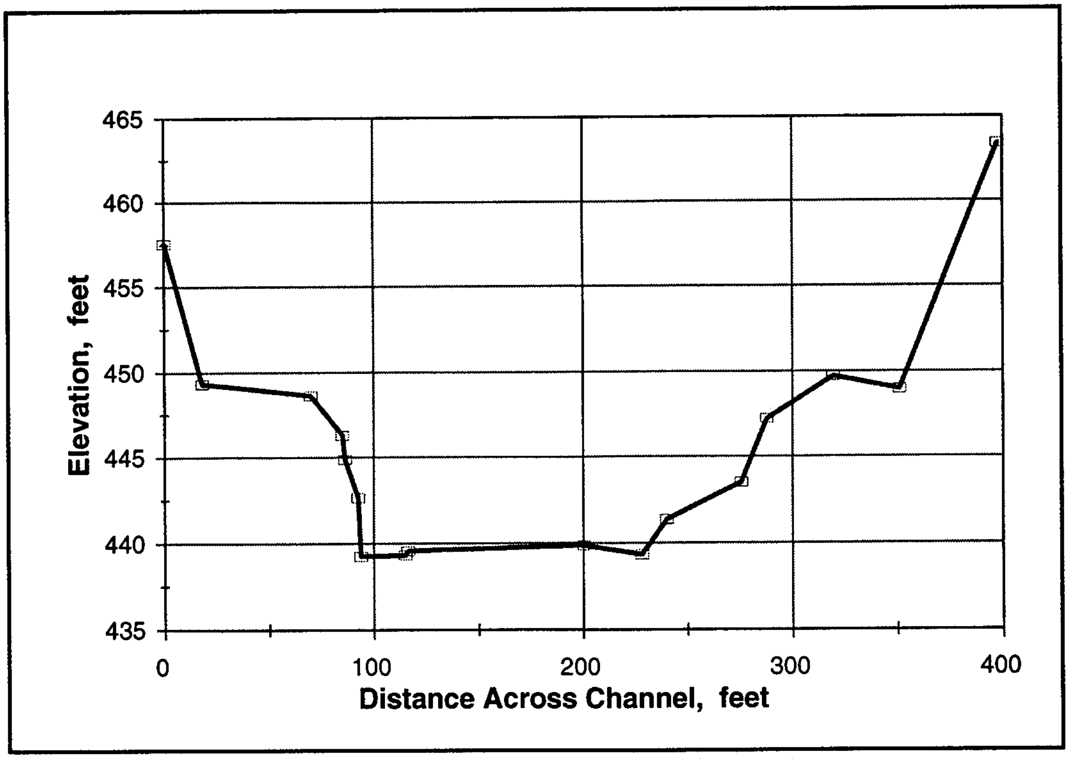

Figure 13. USGS measured cross section no. 1.5.

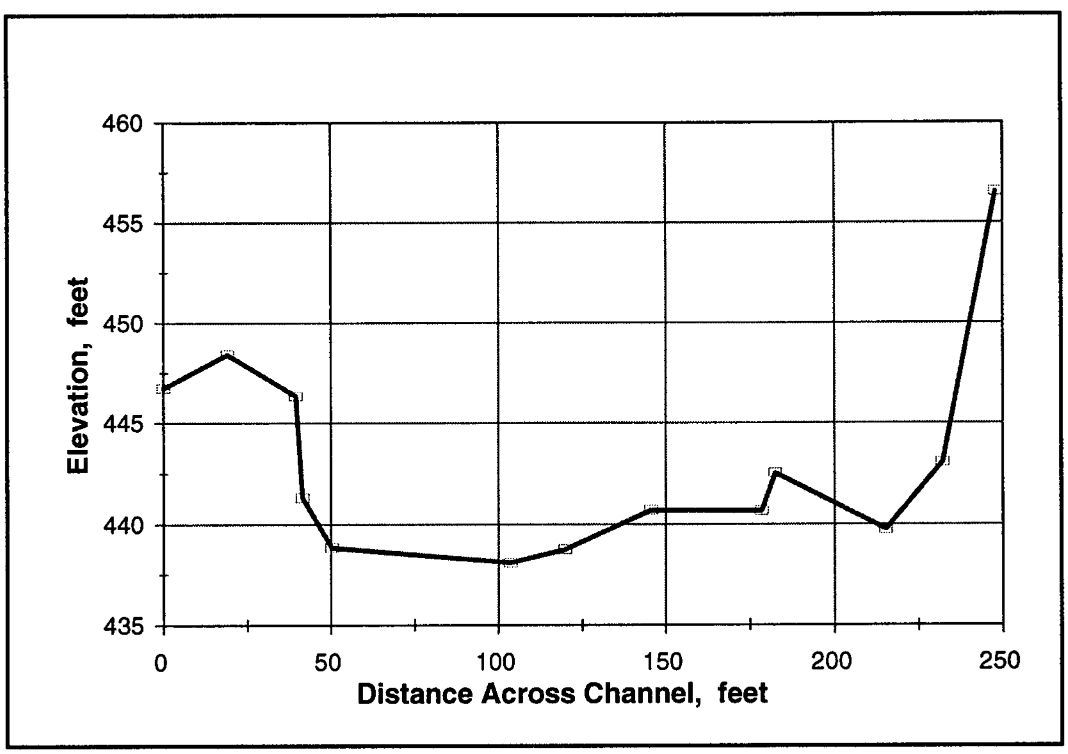

Figure 14. USGS measured cross section no. 1.

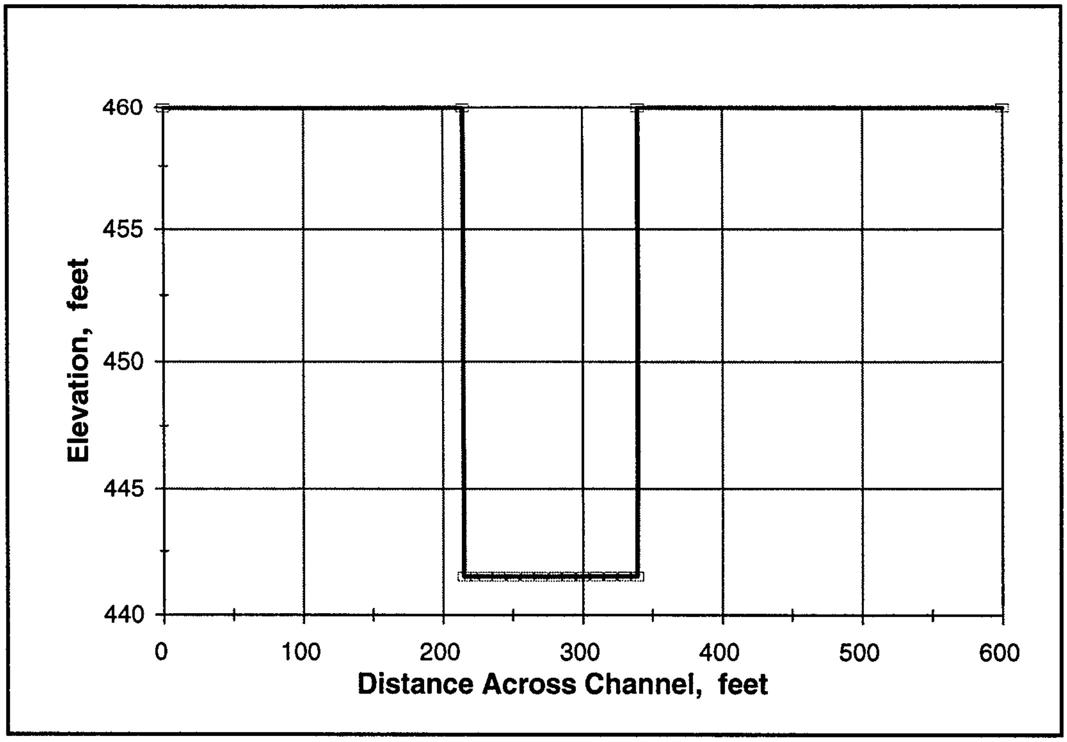

Figure 15. Generated cross section for bridge location at 830.3 ft.

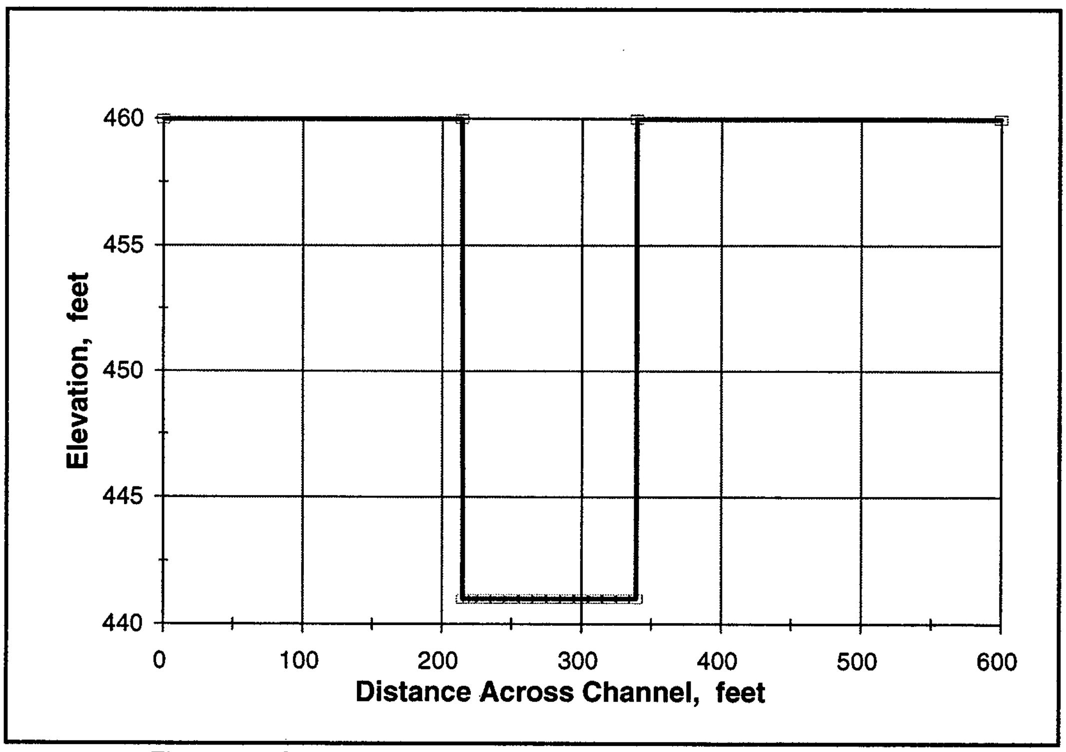

Figure 16. Generated cross section for bridge location at 675.5 ft.

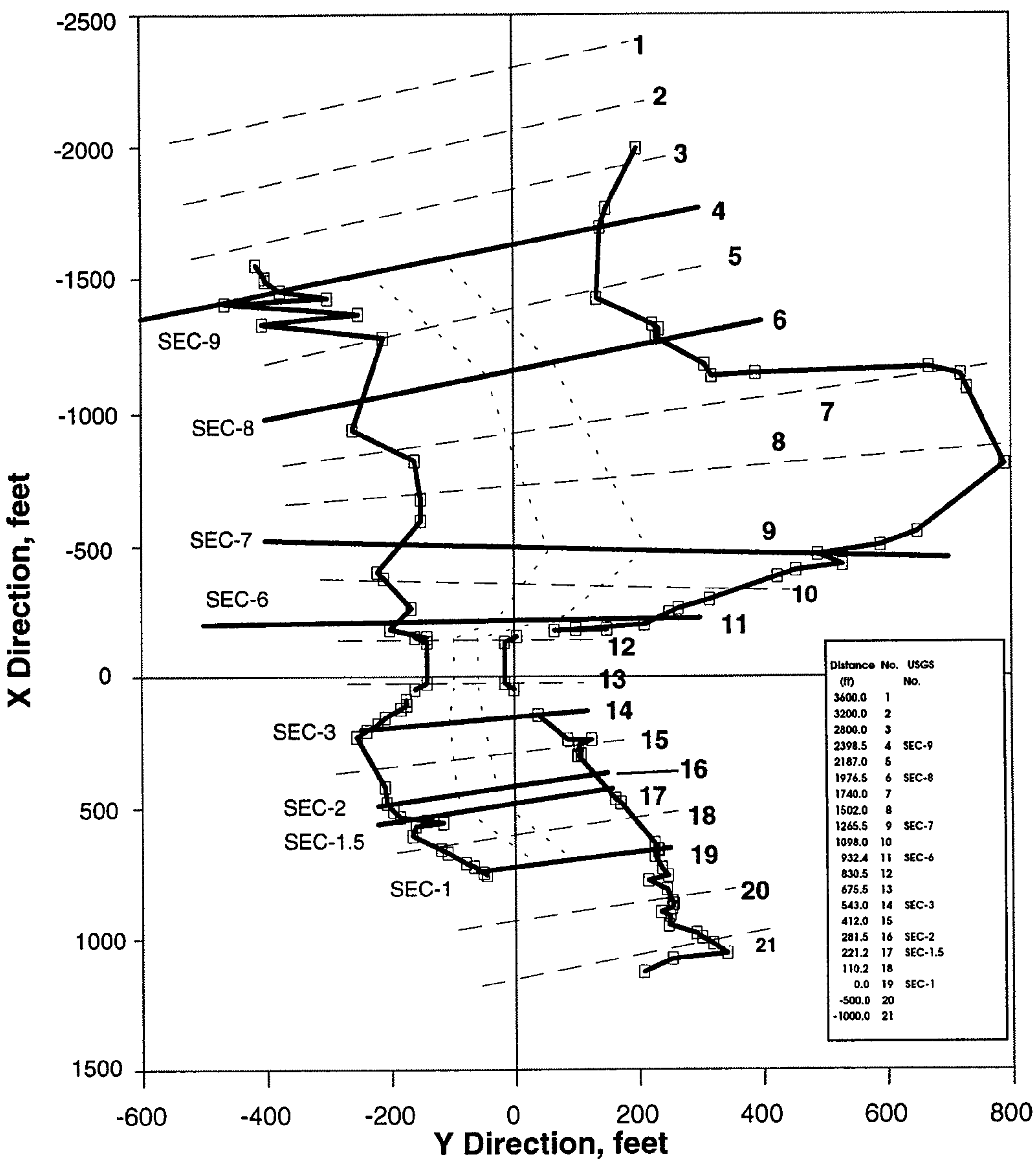

Figure 17. Plan view showing locations of interpolated and propagated cross sections.

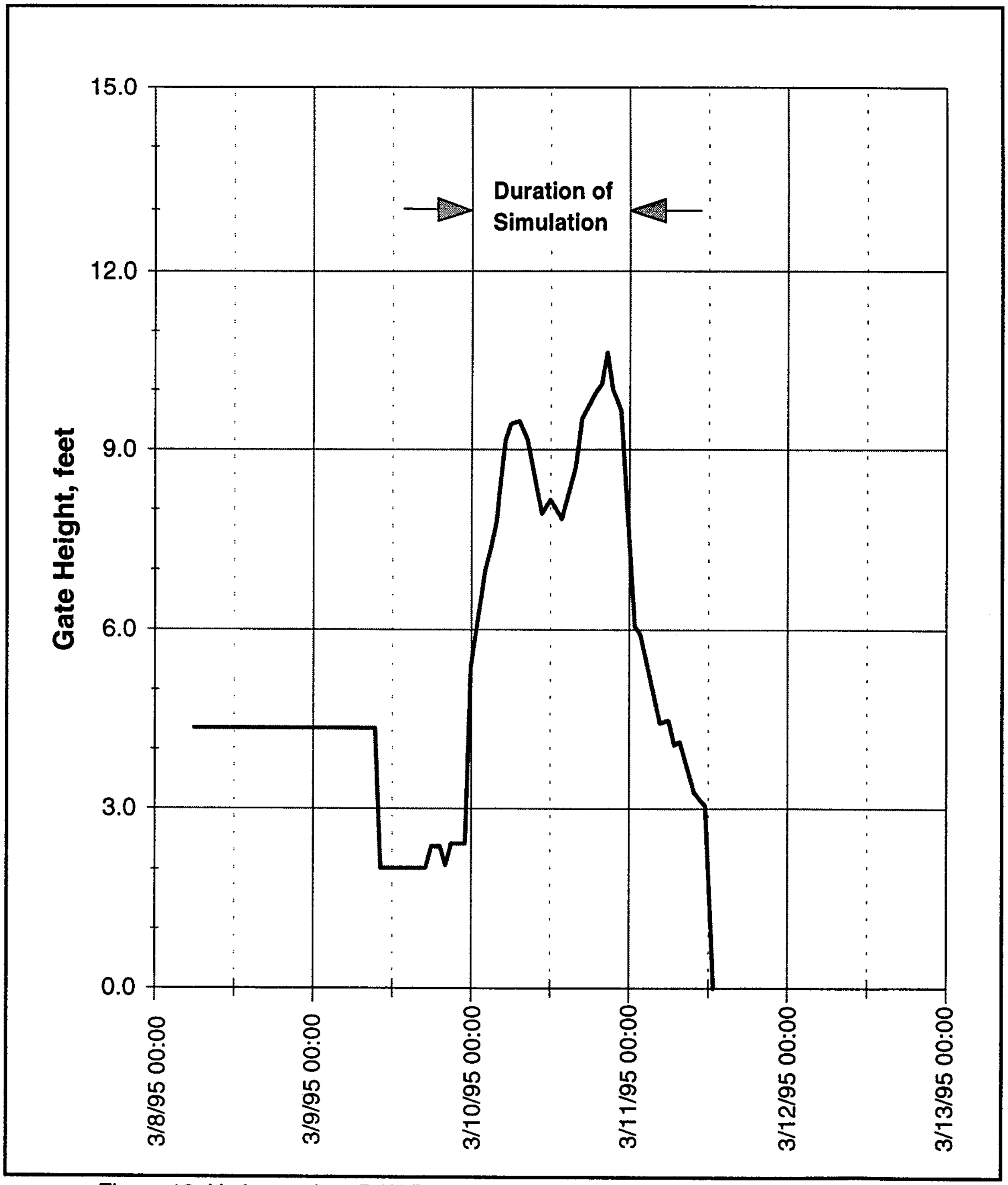

Figure 18. Hydrograph at D.W.R. station, Los Gatos Creek at Eldorado Avenue.

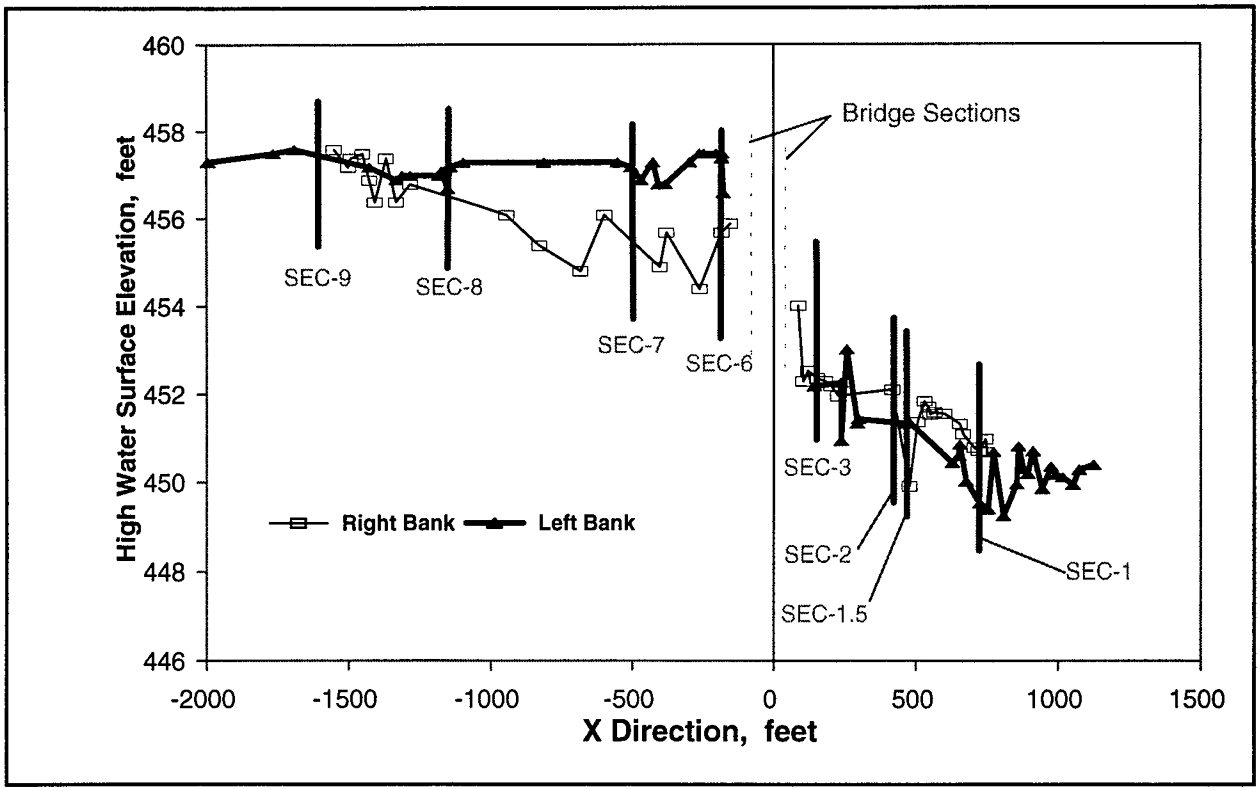

Figure 19. High water surface elevation measured on March 20 and 21, 1995.

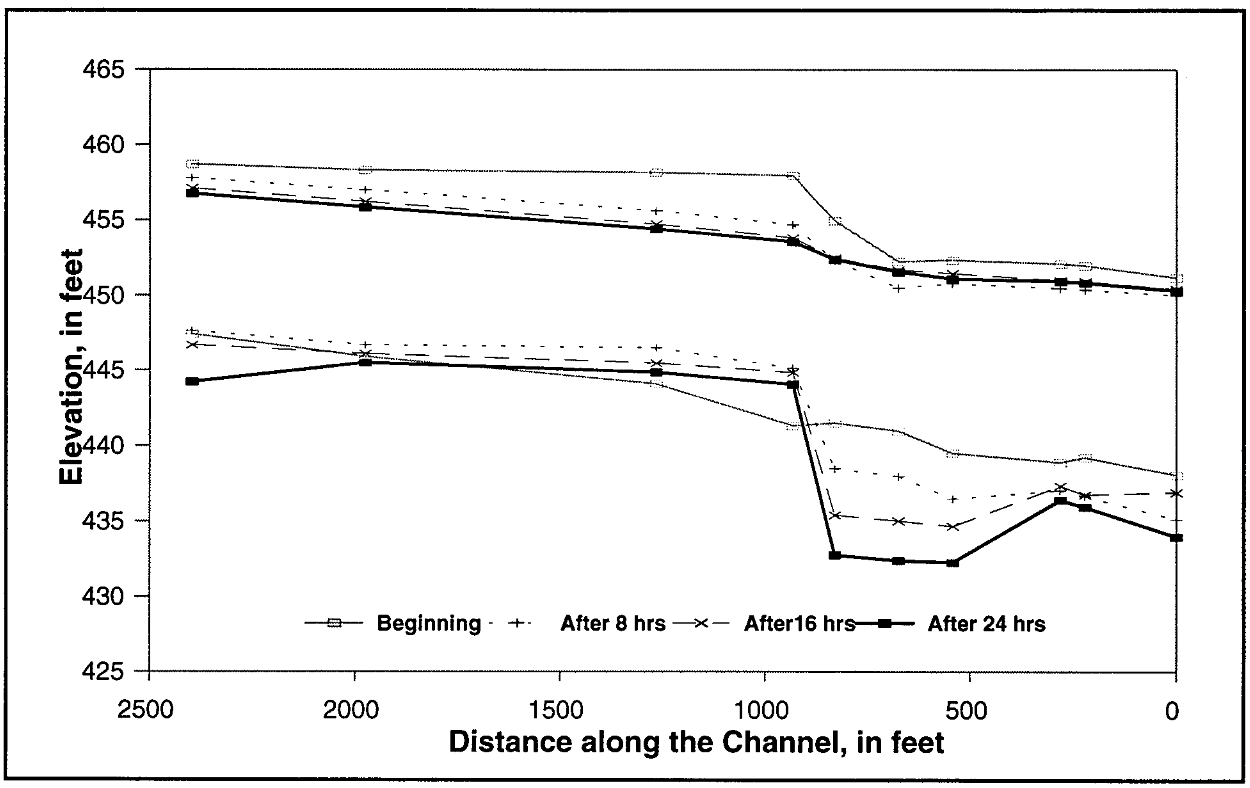

Figure 20. Water surface and bottom profiles computed at different times.